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SPECIAL ACCOUNTS

summing up the reports on the questions for discussion at the eleventh session of the International Railway Congress Association (Madrid, 1930).

SECTION I. — Way and works.

[624 .63, 625 .142.4 721 .9]

QUESTION I.

(THE USE OF CONCRETE AND REINFORCED CONCRETE ON RAILWAYS),

by F. B. FREEMAN,

Special Reporter.

A. — Concrete sleepers.

Summary and conclusion from Report No. 1, by Mr. Jullien, Engineer in Chief, for the Permanent Way and Works of the Paris-Orleans Railway, and Mr. Claise, Director in Control of Works on New Lines and of Railway Track and Buildings at the French Ministry of Public Works (1) is given below. This report covered *Belgium, France, Italy, Portugal, Spain and their Colonies and Switzerland.*

« Of the numerous types of reinforced concrete sleepers which have been tried,

(1) See *Bulletin of the Railway Congress,* October 1929 number, p. 1959.

a certain number have been abandoned, many again have been in use too short a time to permit of a definite opinion being expressed; certain types, however, have been extensively used on lines with light traffic notably those of the French Railway Companies. Reinforced concrete sleepers have begun to be used on lines with heavy traffic at fairly high speeds, but these trials have not been under way long enough for any definite conclusions to be formed. The question remains more or less open as regards their use on lines carrying heavy, fast and numerous trains and it is on such lines that trials should be continued. The price delivered on the work is higher for the reinforced concrete sleeper than for that of wood, but it is hoped that on lines with light traffic the increased price will be compensated for by longer life and lower maintenance. Experiments should be undertaken dealing with the methods of rail attachment and on the advantages and drawbacks of the various kinds of ballast from the point of view of the life of the sleepers. »

Summary and conclusion from Report N° 2, by Mr. F. B. Freeman, Chief Engineer of the New York Central Railroad (2) is given below. This report covered *America, Great Britain, Dominions and Colonies, China and Japan.*

« A study of the detail reports received from the various countries indicates that reinforced concrete cross-ties (sleepers) are still in the experimental stage and have not up to the present time proven a satisfactory or economical substitute for treated wooden cross-ties. Insofar as the countries covered in this report are concerned, namely, Africa, Argentina, Australia, Brazil, Canada, Ceylon, Chili, China, Great Britain, India, Ireland, Japan, Malaysia, Mesopotamia, Salvador, United States and Uruguay, while many different designs of reinforced concrete cross-ties have been tried, none have proven entirely satisfactory. However, experiments are being continued covering the sleeper construction as well as the reinforced concrete roadbed, and it is believed that in the light of past experience, a satisfactory design will be evolved. It appears, however, that the use of such construction will have to be for other reasons than economy, except in a few countries where wooden sleepers are scarce or relatively more costly. »

Summary and conclusion could not be formulated for the countries covered by *Report No. 3*, by Mr. E. Krick, Engineer, Inspecting Officer at General Headquarters of the State Railways of the Kingdom of Yugoslavia (1). This report covered all countries except those listed above. However, an excerpt from this report is given below :

« The Danish State Railways report that... out of the 2 000 sleepers in reinforced concrete laid in 1905 on the principal lines, about 700 are still in service, from which it may be concluded that their average life is 18 years... the results obtained were not satisfactory from a technical point of view,... and at the present time it is still more economical to use wooden sleepers in Denmark. »

Reports 1, 2 and 3 indicate very interesting developments and show extensive experimentation with concrete sleepers. A condensed summary is given below in table I from which it is to be noted that over 800 000 sleepers are reported or, in other words, over 300 miles of track have been laid on concrete sleepers.

(2) See *Bulletin of the Railway Congress*, May 1929, number, p. 433.

(1) See *Bulletin of the Railway Congress*, December 1929 number, p. 2975.

TABLE I.

Summary of reports on concrete sleepers.

Country.	Number of sleepers reported.	Types of sleepers reported.	Duration of test or service and number of sleepers reported still in service.		
			15 years or longer.	10 years or longer.	Less than 10 years.
Ceylon	2 600	3	—	—	2 600
China	Few	1	—	—	Few
Czechoslovakia . .	Few	1	—	—	Few
Denmark	2 000	—	700	700	2 000
France	300 808	16	140 048*	140 048*	300 808
Great Britain . . .	196	5	—	Few	196
India	Few	2	—	—	Few
Ireland	86	1	—	36	36
Italy	480 866	15	300 000*	302 050*	480 866
Japan	150	1	—	—	142
Spain	Few	2	36*	36*	Few
Switzerland . . .	1 901	4	1 000*	1 490*	1 901
United States . .	17 549	26	2 658**	6 253**	17 402

* Not co sidered successful.
** 795 not considered successful.

Some of these sleepers were installed as early as 1901 and while only a very few of the earlier types are still giving good service, the later and more recent installations which are in general based on improvements made in the earlier types give some promise of success. Considerable study has been given by the experimenters in various parts of the world to improvements in the method of rail support and fastening. The later designs indicate that the need for resiliency in these fastenings is recognized. The shock, jar, and wave motion as well as the longitudinal and cross movements produced in the rail, sleepers and ballast must be provided for. In addition there is also the necessity of securing proper electrical insulation between the rails where track circuits are used. A tendency to favor the elimination of the center solid portion of the sleeper or to suppress center tamping is noted. Some of the more successful types which are still in service or which have been modified to overcome defects developed in the earlier installations and are still retained, are listed below.

Bates concrete sleeper used by the Elgin, Joliet and Eastern Railway at Whiting, Indiana, U. S. A., weighs 453 lb. and consists of two reinforced concrete blocks (1 : 2 : 3 mix) 7" × 9" × 3'-0", one under each rail, connected by two specially formed steel trusses which are part of the reinforcement. Sleepers are spaced 1'-6" center to center and laid on gravel ballast. A vulcanized fibre pad is used between the sleeper and rail and the fastening consists of two hook bolts keyed with wooden blocks. Sleepers have been under heavy freight traffic since 1912 and are reported as giving good service.

« *Blochetti* » *F. S. 1925 pot sleeper* used on the Italian State Railways weighs 260 lb. and consists of two reinforced concrete members approximately 6" × 8" × 2'-4" connected by a flat steel tie bar across the top. The rail is fastened to the sleeper by means of two coach screws which engage steel spirals cast in the concrete. Trials are too recent to give final judgment.

Brown concrete sleeper used by the Pennsylvania Railroad, U. S. A., developed from the « Casey » sleeper, weighs 600 lb. and consists of a single member of reinforced concrete (1 : 1.8 : 2.4 mix) 9" × 10" × 8'-0". Oak blocks are placed between rail and sleeper and the fastening consists of two spikes driven into creosoted oak spike blocks. Sleepers are spaced 1'-10" center to center and laid on stone and cinder ballast. The earlier types were not successful and the later types have not been in service long enough to judge their value.

Calot concrete sleeper under test since 1909 by the Paris-Orleans Railway and also experimented with on French Est, State and Nord Railways. The modified type used by the French Nord weighs 770 lb. and consists of a reinforced concrete block (1 : 2 : 3 mix) 8" × 12" × 8'-0". Sleepers are laid in ballast and wooden packing piece is placed between rail and sleeper. All lines employing this type excavate a trench midway between the rails so that the sleeper shall not be packed under its center. Fastening consists of two screw spikes in creosoted hornbeam treenail. The earlier types have not given complete satisfaction but the modified types give promise of success.

Maine concrete sleeper used by the Bangor and Aroostook Railroad at Hudson, Maine, U. S. A., weighs 443 lb. and consists of two reinforced concrete blocks (1 : 1 1/2 : 1 1/2 mix), 6 1/2 × 10" × 3'-0", connected by two 1" diameter round rods. Sleepers are laid on gravel ballast. Rail fastening consists of specially designed lock. Sleepers have been under high speed heavy passenger and freight service since 1923 and are reported as giving good service.

Vagneux composite type used by French Est Railway weighs 458 lb. and consists of two reinforced concrete blocks (1 : 1.6 : 3.2 mix) connected by an I-beam of standard section. A wooden packing is used between the rail and the sleeper and the fastening consists of coach screw placed in a hard wood ferrule screwed into a Thiollier spiral fitting. Sleepers are laid on ballast and spaced 2'-5" center to center. This sleeper has been the subject of extensive trials and appears likely to survive.

Valeri longitudinal sleeper (fixed *type)* used by the Italian State Railways between Orti and Chiusi weighs 1 510 lb. and consists of two longitudinal blocks 8" × 2'-0" × 3'-8" held together by two steel bars placed at each end. Trials are too recent to give final judgement.

The weight of some of the sleepers which seem to be favored in recent installations are as low as 443 lb. and in the case of the Blochetti F. S. 1925 as low as 260 lb. This compare with a weight of approximately 240 lb. for a creosoted 7" × 9" × 8'-6" hardwood tie.

The first cost and life which are involved in the ultimate economy of concrete sleepers are still unknown and cannot be determined until a satisfactory design is produced. The following is an excerpt from Report No. 1 :

« ..., we would point out that according to an estimate which was given us in November 1928, the cost price of the Vagneux sleeper would be 55 frs. The French Administrations state that at the present time the price of a wooden sleeper (oak or beech) varies in different districts, and according to the quantity of creosote used, between 35 and 56 frs. In a general way it can be said that the first cost of a concrete sleeper is considerably more than the wooden sleeper, but it may be expected that a line sleepered in reinforced concrete will cost less to maintain and last longer. It is therefore possible that in the end the cost of concrete sleepers per annum will work out to be neither more nor less than the wooden one. »

Assuming that a design is otherwise satisfactory it will be necessary to consider methods of increasing the life beyond that of a creosoted wooden sleeper or else securing a lower first cost for the concrete sleeper. If failure from mechanical wear can be prevented, longer life can no doubt be secured by use of richer and denser concrete and by use of protective coatings. This will be particularly true where sleepers are subjected to brine drippings and repeated freezing and thawing action. As to securing a low first cost, standardization and mass production at central plants will no doubt accomplish this.

CONCLUSION.

Considerable progress has been made in concrete sleeper design. The detail of rail support and fastenings and the suppression of center ballast have been given particular study. The recent installations provide resiliency at the rail support and at the same time secure electrical insulation between the rails. The suppression of center ballasting and elimination of center solid portion of sleeper have reduced the weight as well as the cost and also produced a sleeper better able to withstand shock and vibration. The present status of this very important question appears very encouraging but the problem is by no means solved. Experiments and study should be diligently continued so that we may hope to be nearer the final solution at our next session.

B. — Buildings.

Summary and conclusion from Report No. 1 by Mr. Jullien, Engineer in Chief for the Permanent Way and Works of the Paris-Orleans Railway and Mr. Claise, Director in Control of Works on New Lines and of Railway Track and Buildings at the French Ministry of Public Works (1) is given below. This report covered *Belgium, France, Italy, Portugal, Spain and their Colonies and Switzerland.*

« From our enquiry as a whole, it appears that if since the Rome Congress the use of concrete and of reinforced concrete has been largely used on the railways, for building road bridges and even railway bridges of small span, these materials have only been used exceptionally for railway bridges of medium and long spans. This type of structure appears none the less likely to develop; the use of super cements and of the modern methods of construction that we have noted, cannot fail to facilitate this development.

» On the other hand it has been found that many structures in reinforced concrete show more or less serious damage as a result of the action of smoke. Steps

(1) See *Bulletin of the Railway Congress*, October 1929 number, p. 1959.

should be taken to protect the structures, wherever this action is to be feared, as when damage occurs, the repairs are very difficult and very costly. »

Summary and conclusion from Report No. 2 by Mr. F. B. Freeman, Chief Engineer of the New York Central Railroad (2) is given below. This report covered *America, Great Britain, Dominions and Colonies, China and Japan.*

« The reports indicate a growing use of concrete and reinforced concrete for general building construction. Many buildings have been constructed entirely of concrete and have given excellent service. The cost of such buildings, however, has often been found to be greater than combinations of steel frame and concrete or brick. Nevertheless, the value of concrete and reinforced concrete for floors and platform construction and as a fire resisting material is universally recognized. Some failures are reported, but these are in general due to improper design, improper materials, or poor workmanship, and it is noted that in the more recent installations these features are being given more careful consideration. Dense concrete, secured by control of water-cement ratio and grading and regulation of the mix, is of prime importance and it is generally felt that greater strength, permanence and serviceability can be obtained along these lines. With more attention given to these fundamentals and with increasing knowlegde of their value will come added confidence in concrete and reinforced concrete construction. »

Summary and conclusion from Report No. 3 by Mr. E. Krick, Engineer, Inspecting Officer at General Headquarters of the State Railways of the Kingdom of Yugoslavia (3) is given below. This report covered all countries except those listed above.

« The possibility of using reinforced concrete for the different constructions on railways does not lend itself to general and detailed conclusions;... It has however been shown in a general manner that concrete and reinforced concrete, thanks especially to their low cost of maintenance, have found with good results their largest use on railways for constructions of the most varied types. The complete success depends upon good and accurate carrying out of the work and it is essential that the work should be very carefully and intelligently supervised. This should be especially so in the case of bridges and other structures over which trains run, as these works have not only to carry the dead load but also dynamic stresses difficult to calculate... The demolition of reinforced or ordinary concrete structures is not only more difficult than those of other materials, but gives material without value and difficult to dispose of. »

A list of the countries from which detail reports were received is given below together with the nature of the structures reported. Extensive use of concrete and reinforced concrete is noted. The reason for the use of concrete is in general on account of the desire to secure structures of greater permanence, to reduce fire hazard and reduce maintenance. In many cases, concrete is more economical and better suited structurally. Furthermore, the technique of concrete and reinforced concrete has been improved by new methods of construction by which the railway companies have profited.

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(2) See *Bulletin of the Railway Congress*, May 1929 number, p. 433.

(1) See *Bulletin of the Railway Congress*, December 1929 number, p. 2975.

Summary of reports on concrete and reinforced concrete structures.

Africa, Artizans' quarters, floor construction and walls.

Argentina, Locomotive shed and water tanks.

Asia, Staff quarters, station buildings and hospital.

Belgium, Bridges and viaducts.

Brazil, Station buildings and platforms.

Bulgaria, Bridges and tunnels.

Canada, Station buildings, cattle and sheep barns, coaling plants, grain elevators and stores building.

Ceylon, Nothing reported.

China, Several large buildings.

Czechoslovakia, Culverts, bridges and tunnels.

Denmark, Bridges, tunnels, chimneys, ashpits, water tanks and sustaining walls.

Egypt, Culverts, bridges and sustaining walls.

Finland, Culverts, bridges and ashpits.

France, Bridges and viaducts.

Great Britain, Goods depots, warehouses, grain stores, water tanks, silos, coal chutes, platelayer's cabins and shunter's huts.

India, Goods sheds, station building, floors, engine sheds and bungalows.

Ireland, Goods shed.

Italy, Bridges.

Luxemburg, Culverts, bridges, locomotive sheds, ashpits, water tanks, portable houses and coal bunkers.

Japan, Nothing reported.

Malaysia, Few minor buildings.

Netherlands, Locomotive round sheds, bridges, chimneys, ashpits, coaling plants, water tanks and sustaining walls.

Norway, Locomotive sheds, ashpits, tunnels and bridges.

Rumania, Roundhouses, ashpits, water tanks and shelter houses.

Spain, Arch and tube bridges.

Sweden, Roundhouses, ashpits, water-reservoirs, culverts, bridges and tunnels.

Switzerland, Viaducts.

United States, Engine houses, coaling stations, pump houses, shops, warehouses, office buildings, freight houses, grain elevators, scale houses, oil houses, shelters, block stations and watchman's huts.

Uruguay, Nothing reported.

Yugoslavia, Roundhouses, chimneys, water tanks, ashpits, wagon repair shops, shelters, culverts and bridges.

Improvements in concrete making (special steels and cements).

Considerable study and experimentation is reported in connection with use of special steels and special cements, such as quick setting and high early-strength cements, as well as with so-called super-cements claimed to produce concrete of greater durability. Also improved formwork, proportioning concrete by accurate control of the water-cement ratio and the more careful selection of well graded fine and coarse aggregates have been given considerable study in the general desire to secure stronger and more durable concrete structures. In this connection, the following excerpts are quoted from the various reports :

Report No. 1. — « Ferro-cements. — Although exclusively used until recent years, the ordinary Portland cement is now replaced, under certain conditions, by special cement known as ferro-cement which has, amongst other features, that of hardening quickly and of showing great strength. The result of its use is to make large savings in shuttering, in addition, owing to the heat re-

leased during setting, it is possible to continue the work during frost. »...

« High tensile steel. — In order to give structures considerable strength and at the same time reasonable lightness, use has occasionally been made not only of super cement, but also of high tensile steel. »...

« On very large works the railway companies have added to the present tensile and compression tests, so as to be certain of the quality of the cement, deflection tests with the object of making certain of constant plasticity and of the suitable addition of water. This has checked the tendency of contractors to use very liquid concrete which is easier to make and use, but which gives lower strength. In this way... the proportions of cement were considerably increased in places where the amount of reinforcement used made it necessary to use a more fluid concrete. »...

Report No. 2. — « ...Considerable study has been given to securing concrete of permanence and durability by using the best materials, by using care in the grading of sand and stone, control of water-cement ratio and field regulation of the mix. »

Report No. 3. — « The development of excellent qualities of steel and their use in reinforced concrete work, steels which do not always give good economic results unless at the same time superior quality cements are used, have acted as a further stimulant to the extended application of reinforced concrete on the railways. »...

« In the form of cement obtained from burning clay, and cements which rapidly attain great strength, a material has been put upon the market which makes it possible to put into service a few days after completion structures in which these cements are used In many cases when it is a question of the construction of bridges or ashpits, repairs to tunnels, etc., this property can be of great importance, as, for operating reasons, it is only necessary to take possession of the line for a very short time for carrying out the work. »

Causes of deterioration and methods of protection.

The various reports indicate that it is generally recognized that concrete and reinforced concrete structures are subject to deterioration under certain conditions when exposed to physical abrasion, alkaline or acidic waters. brine drippings, smoke fumes and weathering under general atmospheric exposure. In such cases, the full life of the structure can be obtained only when the proper protective measures are taken. If deterioration has already occurred, prompt repair measures are recommended. In this connection the following excerpts are quoted from the various reports :

Report No. 1. — « It is the custom to consider as practically negligible, the maintenance required to preserve structure in concrete, or in reinforced concrete, by likening them to structures in masonry. It has however been established that under certain circumstances, structures of this kind have deteriorated. »...

« It is strongly recommended to surround the reinforcements near the facings liable to be affected, by a sufficient thickness of material; it appears that the thickness of this coating should be at least 2.50 cm. (1 inch.). It is essential that the concrete should be very compact and that it should show a very smooth surface. In parts of structures particularly exposed to the action of smoke, the use of « ciment fondu » is advisable The use of coatings of resisting cement (fondu, siliceous) is very efficacious, on the condition that they are properly united to the structure, which requires their application when removing the shuttering. The use of

special paint and protecting coverings can also be recommended. »...

Report No. 3. — « As all the Administrations call attention to the destructive action of the hot ashes and of the alkaline waters on the concrete if the ashes are not collected in special recipients, the lining of the pits in thin brick, ordinary brick, etc., is recommended. »...

« The Danish State Railways have used concrete... in two tunnels The problem of protecting the concrete from the attack of smoke has been very thoroughly investigated, but up to the present no measure of lasting success has been discovered. »...

« The Swedish State Railways have fitted their tunnels running through broken rock with linings in reinforced concrete. As a method of protection against the combustion gases they use coatings of « Inertol » or a layer of cement applied with the cement gun. »

CONCLUSION.

The subject of improvements in methods of concrete making, better cements and aggregates and better reinforcement is of vital importance in the general need for stronger and more durable concrete. These should be given further study as well as the methods of more accurate proportioning by control of the water-cement ratio in order to advance the general knowledge of this very important building material.

[625 .143]

QUESTION II.

(RESISTANCE OF RAILS AGAINST BREAKAGE AND TO WEAR) [1],

by Mr. CAMBOURNAC,

Special Reporter.

Three reports were drawn up on the above question, namely :

Report No. 1 (America), by Mr. R. B. ABBOTT [2] ;

Report No. 2 (all countries except America, the British Empire, China and Japan), by Messrs. CAMBOURNAC and PATTE [3] ;

Report No. 3 (British Empire, China and Japan), by Dr. MATSUNAWA [4].

COMPARATIVE SUMMARY.

The three reports referred to above may be compared and summarised as follows :

A. — First causes of rail breakage; measures taken to reduce the number of breakages, both as regards the way rails are used and the conditions of inspection.

I. — International statistics on rail breakage.

A study of the initial causes of rail breakage must be preceded by the recording and classifying of actual cases of breakage.

With a view to facilitating comparison of the observations made in different countries, it was recommended at the Congress held in London in 1925 that they should be grouped in the form of statistical tables. This recommendation has been followed, and the *Bulletin* of the Association has each year published tables in respect of a considerable number of railway administrations.

The first question which arises is :

Is it desirable to continue the publication of these tables and, if so, what modifications, if any, should be made in the tables ?

The American reporter has not raised this question and it may, therefore, be assumed that he is in favour of continuing the publication of the tables in their present form.

The French reporters are in favour of continuing publication, but of modifying the tables in the following manner :

— prepare three distinct tables instead of a single table : rails on surface lines, rails laid underground, totals ;

— give the number of tonne-kilometres;

— give the percentage of rail breakages on straight line and on curves, distinguishing in the latter case between breakage on inner and outer rail ;

— discontinue the distinction between rails with and without oval stain.

Indicate whether the broken rails with part old fracture extending to the surface of the head of the rail showed superficial fissures or not.

A specimen of the proposed form of tables is given as an appendix to the general summary below.

(1) Translated from the French.

(2) See *Bulletin of the Railway Congress*, May 1929 number, p. 483.

(3) See *Bulletin of the Railway Congress*, October 1929 number, p. 2011.

(4) See *Bulletin of the Railway Congress*, August 1929 number, p. 1157.

The Japanese reporter has not dealt with the question directly, but the form of the questions addressed by him to the railway administrations appears to indicate that he considers the present tables inadequate.

After classifying breakages into six different types, according to the aspect of the fracture, he has endeavoured to compare the numbers thus obtained :

a) with the number of trains and with the axle loads running over the rails ;

b) with the age of the rails;

c) with the line elevation (gradients of 10 mm. per metre (1 in 100) and above — other gradients and level line) ;

d) with the line plan (curves of 800 m. (40 chains) radius and above — other curves and straight line);

e) with the chemical, physical and mechanical characteristics of the rails;

f) with the position of the break — inside or outside the fish plates ;

g) with the temperature at the moment of breakage.

Few administrations replied to these questions, and it does not appear that the replies which were received are in any way comparable from the point of view of the information given. If the international statistics on rail breakage are to have any value whatever, they must, in fact, be limited to a small number of headings of a global and essential nature.

It is obvious, of course, that each administration, being in a position to appreciate the details of its own case, has every interest in amplifying and developing its statistics so as to take into account the quality of the rails and the varying conditions under which they are used. In this connection the suggestions of the Japanese reporter are deserving of particular attention.

II. — Observations and investigations in regard to the breakage of rails and its causes.

The American reporter indicates as direct causes of rail breakage :

— transverse fissures;

— cracks due to rolling;

— folds in the foot of the rail;

— the excessive stresses produced in the metal during finishing in the mill;

— inadequacy of cross section in relation to the load to be carried ;

— inadequate attention to permanent way maintenance;

— reduction in cross section resulting from corrosion or rusting ;

— excessive lateral wear at curves;

— mechanical damage caused by defects in rolling stock;

— defective balancing of locomotives.

The reporter has given no information in regard to the very active researches which have been carried out in America since the last Congress in regard to internal transverse fissures (oval stain). It is to be hoped that this gap will be bridged and that the railway engineers will have an opportunity at the Madrid Congress of appreciating the remarkable work done in this connection by their American colleagues.

The French reporters have described the systematic investigations which have been undertaken in France, by a commission consisting of both railway engineers and metallurgists, in regard to rails broken or damaged in service. These investigations have made it possible to lay down the following as the principal causes of rail breakage and defects :

— the inclusion of steel foreign to the cast ;

— longitudinal splitting in the foot of the rail;

— defective rolling (flaws, cold shot, etc).;

— piping and segregation;

— internal transverse fissures with oval stain;

— superficial fissures in the head of the rail (hair cracks).

These investigations have not led to the formulation of any general conclusions in regard to the internal transverse fissure (oval stain), which if of rare occurrence in France.

On the other hand, they have comprised a series of experiments and tests relative to the production of superficial fissures (hair cracks) on the running surface, and to the extension of these fissures in rails of different kinds, whether thermically treated or not.

The Japanese reporter extended his investigations to cover certain factors productive of defects :

— internal transverse fissures (oval stain) which have been dealt with in a memorandum by Mr. Shôji Ikeda, Engineer of the Japanese Railways. This memorandum demonstrates that the internal transverse fissure is a breakage due to repeated stress, starting from the interior of the rail and originating at a point situated below the work hardened part of the running surface. This fissure is assisted by the impurities and blow holes in the metal, but these alone are not sufficient to start it;

— superficial defects (marks made during rolling, folds, etc...), which necessitate the withdrawal of a large number of rails and are due to imperfect or uneven rolls;

— corrosion, which is very active in the case of underground lines, where the atmosphere is laden with moisture and acid products. It is equally active near the sea;

— stresses in rails in service, which vary very rapidly, sometimes even changing direction when locomotives run over them. This is particularly the case on curves, where considerable transverse stresses are developed.

Rail stress tests which have been carried out by certain of the administrations consulted show very varying and sometimes, indeed, contradictory results (e. g. comparison of steam locomotives and electric locomotives). This is not surprising in view of the large number of factors which go to produce stresses in rails. In view of these results it will be interesting to know more about the various appliances which have been used in the tests and, in particular, that which has been used by the Japanese Railways, and which will be made the subject of an article in the *Bulletin of the Railway Congress*.

To the extent to which it may contribute towards an improvement in the cross section of rails and the methods of track laying generally, the determination of stresses obtaining under service conditions is to be strongly recommended and should be pursued by the various administrations with the aid of suitably perfected apparatus.

The Japanese reporter has further studied the resistance of rails in endurance tests Rails are subjected, under actual service conditions, to repeated and varying stresses, with extreme rapidity, and within wide limits. Laboratory tests are therefore those to be carried out to ascertain how rail steel resists this kind of stress. The difficulty here is that the testing process is slow and prolonged. A communication by M. Shôji Ikeda, Engineer of the Japanese Railways, indicates that the electric resistance of a steel test piece, subjected to increasing stresses, remains constant until the stresses reach a value which is lower than the limit of elasticity and which would constitute precisely the « limit of endurance » under repeated stresses.

If this electric property of the steel is confirmed it will be possible to multiply the endurance tests and thereby to relate the limit of endurance to the chemical, physical and mechanical characteristics

of the metal. From a preliminary series of tests, M. Shôji Ikeda has deduced that this limit of endurance should be proportional to the carbon content of the steel.

It is desirable that these endurance tests should be continued and amplified for, of all the present day inspection and laboratory tests, these are the ones which most nearly reproduce the actual conditions of rail stress experienced under service conditions. and it is from them, therefore, that it should be possible to draw the most exact indications as to the manner in which rails will behave.

III. — Methods to be adopted to reduce the number of cases of rail breakage.

The American reporter recommends:

— increasing the sleepering, which should have 18 or even 20 sleepers per rail of 33 feet (10 metres);

— efficient permanent way maintenance to ensure that the joints are kept in good order and to verify the alignment and levelling of the rails, the exact super-elevation of the outer rail, the correct laying in of transition curves at the beginning and end of curves, and all conditions capable of exercising any effect upon the life of the rails;

— daily inspection of main lines, and more often if circumstances require it;

— the use of mechanical appliances for loading, unloading and laying rails;

— the use, on lines where traffic is relatively light or consists of slow-running goods trains, of rails made from the top of ingots.

The reporter makes no reference to the Sperry detector which, according to statements in American publications, detects even very small internal transverse fissures in rails in service, thereby making it possible to withdraw the affected rails from the track before they break.

The American Engineers will doubtless be able to give interesting data with regard to the actual service at present being given by the Sperry detector.

They will also be able to inform the forthcoming Congress as to the results obtained with rails having a high manganese content (1 to 1.8 %) and with thermically treated rails, which gave extremely encouraging results in tests carried out in 1925 in the United States.

The French reporters recommend the study, in collaboration with metallurgists, of rails broken or damaged in service. This study will acquaint the railway engineers with the possibilities of metallurgy, and will acquaint the metallurgists with the causes of deterioration to which rails are subjected in service. This collaboration is indispensable if progress is to be made, as it reconciles the two professional points of view and creates a common desire to effect the necessary improvements.

The investigations already carried out lead the French reporters to recommend the following measures:

a) in the use of rails:

— increase in the weight of the rail which, for axle loads of 20 to 22 tons, should not be less than 45 to 50 kgr. per linear metre (90.7 to 100.8 lb. per linear yard);

— reinforcement of the sleepering, which ought to comprise from 1 400 to 1 780 sleepers per kilometre (2 253 to 2 863 per mile), the layer of ballast under the sleepers to be increased at the same time to a minimum depth of 0.25 m. (10 inches);

— the normal length of rail to be increased to 18 or even 24 metres (59 ft. 5/8 in. to 78 ft. 9 in.), in order to reduce the number of joints, which constitute the weak point of the rail. At special places, where the effects of variations of temperature are less to be feared, the length of rails may be increased beyond

24 m. (78 ft. 9 in.), particularly by the alumino-thermic welding of joints. There does not appear to be any objection to this increase of length, provided the rails and sleepers are sufficiently heavy and strong;

— use of rails from the ingot head for equipping sections of line least subjected to stress (straight line in preference to curves, sections covered at reduced speeds, etc.);

— laying in rails made from the upper part of the ingot so that the part originally nearest the top of the ingot coincides with the less stressed part of the joint (that which the wheel leaves when running forward);

— inspection at least once a year of rails in service on important lines, in order to withdraw from the track rails which show superficial defects capable of developing into breaks;

— the payment of bonuses to permanent way employees who discover not only broken rails but also rails which are in any way defective;

b) in the manufacture and inspection of rails :

— to dose the steel with suitable additions so as to eliminate as far as possible blow holes whilst pouring;

— to forbid the use of steel scrap for protecting the casting plate at the bottom of the ingot moulds, this scrap forming inclusions which are the cause of defects in rails from the botom of the ingots;

— when casting, to take the precautions necessary to avoid splashing and cold shot, which result in superficial lines and flaws;

— to avoid the rolling of ingots at too high temperatures (« green ingots »), which produces rails having a very uneven cross section, the centre being softer than the rest of the cross section and generally surrounded by a ring of impure metal;

— not to force the speed when blooming, so as to avoid the formation of cracks in the ingot; such cracks, afterwards only imperfectly welded up, result in lines on rolling which, when they occur in the foot of the rail, may cause the complete transverse breakage of the rail;

— to discard from the ingots the part contaminated by segregation and piping;

— to check the original profile and, in service, the shape of the grooves on the rolls, so as to avoid the formation of folds, which may prove a source of danger, particularly when they occur at the junction of the web and the foot of the rail;

— to develop macrographic tests during inspection, whereby the homogeneity of the cross section of the rail can be ascertained;

— to develop elasticity tests, for ascertaining the shortness or fragility of the steel. The results of these tests serve, at the least, as a basis for the granting of « quality premiums ». In this connection it would be most desirable to discover a method of testing capable of application to the entire cross section of the rail;

— to develop the use of heat treated rails which, in the course of prolonged tests carried out in France, have been found to possess much higher resistance, than rails not so treated, to the propagation of superficial fissures and cracks on the running surface, caused by skidding of locomotive wheels, braking or unduly long service (cold work hardening). Several thousands of tons of heat treated rails (principally Neuves-Maisons process, and also Sandberg process) are in use in France and are giving complete satisfaction.

The Japanese reporter, in drawing attention to defects due to folds produced during rolling, implicitly stresses the necessity of correctly designing and maintaining the groove on the rolls so as to avoid the formation of these folds.

As a precaution against corrosion on underground lines, he recommends on the one hand ventilation, and on the other the spraying of the rails with a solution of carbonate of soda to neutralise the acidity of the atmosphere.

As deterioration is most frequent at joints, he recommends that the number of joints be reduced, and that the greatest care be exercised in the fixing and maintenance of fish-plates.

He refers finally to the Suzuky defectoscope, an appliance for detecting internal flaws in rails in service. A communication describing this appliamce will be published in the *Bulletin of the Railway Congress*. The advantages of such an appliance are obvious, and the communication in question will be received with the greatest interest.

B. — Quality of metal used for rails to give normal wear. Conditions governning manufacture and inspection. — Rails : profile and quality, length, weight and cross section of the rails.

I. — Observation and study of wear phenomena.

The American reporter makes no reference to the extent and characteristics of rail wear.

The French reporters have attempted an analysis of the phenomena of wear, by studying separately the different forms of wear in rails in service. They indicate the order of importance of the various forms of wear in terms of the traffic and emphasize two forms in particular as rendering rails almost unfit for continued use : wear caused by hammering and crushing of the metal, accompanied by the formation of pronounced flashes, particularly in the case of the inside rails on curves of small radius; corrugated wear, which may have various causes and assume varied forms, and which is so prejudicial to the working of light railways and tramways.

The Japanese reporter has not dealt specifically with this part of the question.

II. — Possibility of reducing wear in service by improving the quality of the rail metal. Conditions of manufacture and inspection.

The American reporter states that the rails supplied to the American companies are made of Martin steel, according to the current specifications of the American Railway Engineering Association.

He reports that trials are at present being made with heat treated rails and rails which have a high manganese content, but he does not state what results have been obtained.

The French reporters describe the tests which are being carried out in the laboratories and on the lines of several railway administrations with the object of ascertaining what qualities of steel are the least subject to wear in service. Up to the present it has not been possible, with any degree of certainty, to relate resistance to wear with any given chemical, physical or mechanical characteristic of steel capable of demonstration by the ordinary laboratory tests, and, in general, all that is done is to select rails having a higher tensile strength when it is desired to increase the resistance to wear.

The specifications prescribe for general use on ordinary lines steels giving : $R \geqslant 70$ kgr. (44.4 Engl. tons per sq. inch).

Extensive and successful trials have been made with heat treated rails (Neuves-Maisons and Sandberg processes) and, in points and crossings where the running surface is not continuous, details cast from steel containing 12 % of manganese and from nickel-chromium steel.

In order to reduce corrosion in rails on underground lines, trials have been

made with rails containing 0.3 % of copper. The results are not yet known.

Finally, the most recent observations appear to show that rails, the running surface of which is, by heat treatment, given a martensitic texture, are not subject to corrugated wear.

The Japanese reporter mentions the conditions laid down by the administrations consulted by him as regards the inspection of rails, but is unable to formulate therefrom any conclusions from the point of view of the influence these conditions may have upon the resistance to wear.

Several administrations have carried out tests in the permanent way with manganese, chromium or silicon steel rails, as also with rails heat treated by the Sandberg process. The manganese steel rails work harden much more rapidly than carbon steel rails and become much harder; of all the special kinds of rail considered, these are definitely the best.

Rails made of silicon steel have not up to the present shown more resistance to wear than carbon steel rails. Chromium steel rails appear likely to last twice as long as rails made of carbon steel, but it is reported that they show signs of brittleness. Sandberg sorbitic steel rails have a life about 20 % longer than rails made of carbon steel.

These observations, made on the permanent way, have been supplemented by laboratory tests carried out by means of the Amsler testing machine and also of an instrument invented by Dr. M. Suzuky. The results of these tests will be made known in a later publication. Further, experiments have been initiated by the Japanese Government Railways, by making a one-ton electric vehicle run round a circular track of 22.4 m. (73 ft.-7 in.) diameter and 0.46 m. (1 ft.-6 1/8 in.) gauge. These experiments have shown, first of all, that it is advisable that the rail should have the same percentage of carbon as the tyre; the experiments are still in progress, and the results will be published in due course.

III. — Most suitable section of rail, and conditions to be observed in its use in order to reduce wear.

The American reporter indicates that the sections used in America are : either the standard sections or sections of each individual railway company. On lines where traffic is heavy the rail generally used weighs 64.5 kgr. per m. (130 lb. per yard). The usual length is 11.90 m. (39 feet). Certain railways of Central and South America use 12.20-m. (40-foot) rails. Some railways have even used 20.10-m. (66-foot) rails with satisfactory results both as regards economy and smooth running.

The French reporters state that the shape of the head of the French standard type of rail was determined after examination of the forms of wear found in the head of rails in service. These forms of wear proved to be almost identical, on straight sections, on the different lines. Wear must be diminished if, at the outset, the running surface of the rail is given the form which it tends to assume in service.

The reporters recommend that particular care be exercised in keeping the rail fastenings tight, so as to hinder any hammering of the rail on its supports and to reduce the wear of the foot of the rail through scaling resulting therefrom.

They refer to the lubrication tests carried out in various countries with a view to reducing wear of rails on curves. For this purpose use is made of appliances fixed either on the track or, for preference, on the engines, to lubricate the lateral surface of the rails and tyres. These tests appear to be giving favourable results.

They further report that check rails on curves tend to disappear and that, where they are still in use, it is not so much with the object of reducing the

lateral wear of the rails as to minimise the consequences of a possible derailment.

They also refer to the use by several administrations, on underground lines or on sections of line which are subject to rapid rusting, of rails having a larger cross section, the surface of which is, in addition, sometimes given a protective covering, generally consisting of tar applied hot as they leave the rolls.

The Japanese reporter indicates the cross sections adopted by the administrations he consulted. They correspond to the British or Australian standard specifications, or to the types adopted by the American Society of Civil Engineers. It is not, however, possible to discover to what extent considerations of wear entered into the determination of the cross sections adopted. It may, however, be noted that in the Australian specifications rails have been designed for curves of low radius which, in order to compensate for lateral wear, have a head 3 mm. (1/8 inch) higher than the head of straight rails.

C. — Rail joints. The most economical and efficient design.

The American reporter notes the adoption by various railways in the United States of a joint formed by means of fishplates with rails left head-free. This joint is based on a new principle : the rail has no upper fishing surface and the upper part of the fish-plates reaches only to the angle of junction of the head and the web of the rail.

The reporter considers that this type of rail and fish-plate is the best that has yet been produced, and that its discovery was a distinct engineering achievement.

This type of fishing has been widely applied; it is now used exclusively on the lines of the Reading Company [2 890 km. (1 796 miles) of main line, very dense traffic, maximum axle loads].

The French reporters point out that in general railway administrations do not prepare statistics of fishplate breakages, and that this is an omission which should be rectified.

They recommend the continuance and development of the comparative tests suggested by the London Congress in so far as concerns the three types of rail joints which at that time were the subject of consideration :

— bridge joints;

— joints supported on sleepers laid side by side;

— joints with which the web of the rail is not drilled.

They report that the second type of joint is being increasingly adopted in Europe.

They refer to the trials which have taken place since the last Congress, with a joint known as the chevron fishplate joint, which is based on a new principle, the application of which will be followed with the greatest interest. It has already been quite widely adopted. The fishplate is short, with only two bolts. Its centre rests on the upper fishing surface of the rails, and its extremities on the lower fishing surface.

As regards the quality of the metal used for fishplates, the reporters remark that, with rare exceptions, the specification conditions laid down by the regulations are not very strict, and there are no particular specifications in regard to the fragility of the metal.

Heat treatment is required by certain railway administrations.

The French reporters have extended their inquiries to cover the method of effecting : on the one hand, the electric insulation of joints and, on the other hand, the electric continuity of a line of

rails notwithstanding the presence of joints. The information obtained by them in this connection indicates that, apart from the experimental use of bakelised wooden fishplates, there have been no innovations since the last Congress. It may be noted, however, that the French Midi Railway, which makes very extensive use of the chevron fishplate, has ascertained that this new type of fishplate is sufficient in itself to ensure electric continuity in a line of rails without the need for any electrical bonding.

The French reporters further inquired as to the quality of the metal used for the manufacture of fish-plate bolts, and as to the methods or arrangements adopted for preventing the loosening of bolts in service, for ensuring that the pressure of the fish-plate against the rail remains reasonably constant in spite of wear of the surfaces of contact, and for facilitating the screwing up of the bolt.

From the replies received it appears that a large number of methods are being experimented with, with a view to solving the problems referred to. Some of the methods appear to be satisfactory, but they have been in operation for too short a period for it to be possible to say that any one method is distinctly superior to the others.

The Japanese reporter gives some statistical data in regard to breakage of fish-plates and arrives at the conclusion that, since the plates generally break in the middle, it would be desirable to strengthen the central section.

As regards the various types of fishplate in use, this reporter has paid particular attention to fish-plates intended for the connecting of two rails of different section, and gives a number of diagrams. He indicates that these fishplates, the central part of which is reinforced, are usually fixed by means of bolts, but that on the Japanese Railways they are rivetted.

The reporter inquired whether any measures had been adopted for determining stresses in fish-plates; he received no replies to this inquiry, but the Japanese Railways have undertaken researches on this subject, the results of which will shortly be published in the *Bulletin of the Railway Congress*.

The reporter also asked the administrations consulted to state the type of joint which they consider the most satisfactory. The administrations have, in general, indicated the type of joint they use, but have given no very definite reasons for their choice.

The reporter, finally, asked what was the chemical composition of the metal used for fish-plates, and what form of thermic treatment was considered the most suitable. The administrations consulted have in general indicated the British and Australian standard specifications.

GENERAL SUMMARY.

The various observations and recommendations relative to Question II (Resistance of rails to breakage and to wear) may be summarised as follows :

1. It is desirable to continue the publication of data relative to rail breakages under the conditions laid down at the London Congress, the tables, however, being modified in accordance with the specimens shown in the appendix.

2. It is highly desirable to continue the observation and study of rail breakages, and it is recommended that this should be done in collaboration with metallurgical engineers.

3. It is desirable that the precautions indicated below should be observed in the manufacture of rails :

a) dose the steel in such a way as to avoid blow-holes;

b) forbid the use of steel scrap at the bottom of the ingot moulds;

c) avoid splashes when pouring;

d) not to roll ingots too hot;

e) not to force the speed when blooming, so as to avoid the formation of cracks;

f) discard from the ingots the part affected by piping and segregation;

g) establish and maintain the profile of the grooves on the rolls with accuracy;

h) reduce to a minimum the cold straightening of rails, so as to diminish the stresses resulting therefrom.

4. It is recommended that the following should be developed :

a) macrographic tests so that the homogeneity of the cross section may be examined. In their present form, these tests can be used for elimination purposes, i. e. for the elimination of rails which are not uniform throughout;

b) elasticity tests for determining the degree of fragility of the metal. These tests, in their present form, do not enable fragile rails to be rejected, but they are already sufficient to serve as a basis for the granting of quality premiums. It would be an advantage if research could be continued in order to perfect a fragility test applicable to the whole cross section of the rail;

c) laboratory research and tests relative to the endurance of rails, i. e. to their resistance to repeated stresses;

d) research and experiments relative to the stresses which develop in rails under passing wheels.

5. The following precautions are recommended in the use of rails :

a) to utilise rails obtained from the head of ingots for those parts of the line which are subjected to the least strain, and to lay them in such a manner that the wheels first run on to them at the end of the rail farthest from the ingot head;

b) to load and unload rails by mechanical means;

c) to inspect the rails in situ, at least once a year, on lines where traffic is intense. It is desirable to perfect appliances for detecting internal defects in rails whilst in service (Sperry detector, Suzuky detectoscope);

d) to use rails which have received suitable heat treatment on sections of line where the rails are subjected to exceptional stresses, to skidding and to repeated braking, rails so treated resisting the propagation of superficial fissurès (cracks in the running surface) better than rails which have not been treated.

6. The length of rails can, without inconvenience, be increased to 24 m. (78 ft. 9 in.), and research and tests should be continued with a view to increasing the length beyond 24 metres (if necessary by means of aluminothermic welding), particularly at special points of the line where the effects of expansion are less to be feared.

7. With a view to reducing normal wear in rails, it appears desirable to give the running surface, when new, the average cross section which it tends to assume in service.

8. With a view to reducing lateral wear on curves, an endeavour should be made to perfect and develop appliances for lubricating the lateral faces of the head of the rail and of the wheel tyre, which come into contact during running on curves.

9. With a view to reducing wear through hammering at gaps in points and crossings, it is recommended that use should be made, in the details of such equipment, of manganese or nickel-chrome steel.

10. With a view to remedying wear

due to rusting, it is recommended that a reinforced cross section be adopted. The tests with steel containing an admixture (0.3 %) of copper should be continued.

11. It is desirable that all railways should continue and develop the comparative tests of rail joints suggested by the London Congress, and that they should extend these tests to the following two new types of joint :

— head- free fish-plate;
— chevron fish-plate.

12. It is recommended that each administration should keep statistics relative to the breakage of the different types of fish-plates used in the comparative tests.

APPENDIX

Names of Administrations and Description of rails.	Less than 5 years.			5 to 10 years.			10 to 15 years.		
	Number of breakages.	Length of single track of this class.	Number of breakages per 1000 km. (625 miles).	Number of breakages.	Length of single track of this class.	Number of breakages per 1000 km. (625 miles).	Number of breakages.	Length of single track of this class.	Number of breakages per 1000 km. (625 miles).
1	2	3	4	5	6	7	8	9	10
. . . . Railway.									
									A. — **Rails n**
Light rails : weighing less than 42.5 kgr. per m. (85 lb. per yard).									
Medium rails : weighing between 42.5 and 52.5 kgr. per m. (85 and 105 lb. per yard).									
Heavy rails : weighing 52.5 kgr. per m. (105 lb. per yard) or more.									
Total . . .									
									B. — **R**
Light rails : weighing less than 42.5 kgr. per m. (85 lb. per yard).									
Medium rails : weighing between 42.5 and 52.5 kgr. per m. (85 and 105 lb. per yard).									

ils.								
15 to 20 years.		Over 20 years.			The whole of the rails.			Maximum axle weight.
Length of single track of this class.	Number of breakages per 1000 km. (625 miles).	Number of breakages.	Length of single track of this class.	Number of breakages per 1000 km. (625 miles).	Number of breakages.	Length of single track.	Number of breakages per 1000 km. (625 miles).	
12	13	14	15	16	17	18	19	20
tunnel.								
tunnel.								

Names of Administrations and Description of rails.	Ag								
	Less than 5 years.			5 to 10 years.			10 to 15 years.		
	Number of breakages.	Length of single track of this class.	Number of breakages per 1000 km. (625 miles).	Number of breakages.	Length of single track of this class.	Number of breakages per 1000 km. (625 miles).	Number of breakages.	Length of single track of this class.	Number of breakages per 1000 km. (625 miles).
1	2	3	4	5	6	7	8	9	10
							B. — **Rails i**		
Heavy rails : weighing 52.5 kgr. per m. (105 lb. per yard) or more.									
Total . . .									
							C. — **Tota**		
Light rails : weighing less than 42.5 kgr. per m. (85 lb. per yard).									
Medium rails : weighing between 42.5 and 52.5 kgr. per m. (85 and 105 lb. per yard).									
Heavy rails : weighing 52.5 kgr. per m. (105 lb. per yard) or more.									
Total . . .									
Number of { train-kilometres . / train-miles . . . . }									
Number of { tonne-kilometres . / ton-miles . . . . . }									

rails.										
	15 to 20 years.		Over 20 years.			The whole of the rails.			Maximum axle weight.
Number of breakages.	Length of single track of this class.	Number of breakages per 1000 km. (625 miles).	Number of breakages.	Length of single track of this class.	Number of breakages per 1000 km. (625 miles).	Number of breakages.	Length of single track.	Number of breakages per 1000 km. (625 miles).	
11	12	13	14	15	16	17	18	19	20

nnel (*continued*).

r *A* and *B*.

Number of breakages	Total	
	per 10 000 000 train-kilometres . .	. . . .
	per 6 250 000 train-miles.	
	per 1 000 000 000 tonne-kilometres.	. . . .
	per 612 000 000 ton-miles	

		Percentage of breakages		Percentage of breakages		
					on curves	
		in the part covered by the fish plates.	outside the joint.	on straight lines or curves of more than 800-m. (40 chains) radius.	lower rail.	higher rail.
D.	Light rails.					
	Medium rails					
	Heavy rails					
	Totals					
	Length of single track of each class . . .					

				Light rails.	Medium rails.	Heavy rails.
E.	a) Sharp clean fracture					
	b) Fracture partly old, much rusted, reaching to the outside surface of the foot, or of the head of the rail.	in the foot				
		in the head . . .	with surface fissurations . . .			
			without surface fissurations . .			
	c) Fracture including an old part much rusted which does not reach to the outside surface of the foot or of the head of the rail. . . .	in the web				

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QUESTION III.

(INVESTIGATION INTO THE STATIC AND DYNAMIC STRESSES IN RAILWAY BRIDGES) (1),

By R. DESPRETS,
Special Reporter.

Reports have been drawn up on this question by :

Sir Henry FOWLER, K. B. E., Chief Mechanical Engineer, London Midland and Scottish Railway, and

Mr. G. ELLSON, O.B.E., Chief Engineer, Southern Railway (Great Britain) (2);

Mr. Alberto FAVA, Engineer, Chief Inspector in the Permanent Way Department of the Italian State Railways (3)

Mr. P. G. LANG, Engineer of Bridges, Baltimore and Ohio Railroad Company (3);

Messrs. A. A. C. RONSSE, Chief Engineer of the Belgian National Railway Company, and

R. DESPRETS, Principal Engineer of the Belgian National Railway Company (4).

* * *

The four reports mainly deal with the question of the dynamic effects on metal railway bridges. Sir Henry Fowler and Mr. G. Ellson add thereto some considerations on the balancing of locomotives; Mr. Fava also deals with the static effects and more particularly the secondary stresses. The present concise report is intended chiefly to summarise the knowledge which has been gained on the dynamic effects and to point out briefly the immediate conclusions.

The dynamic effects in metal bridges have different causes, which may be ascribed either to vibration phenomena due to the passage of loads at speed, or to the shocks resulting from poor maintenance of the vehicles or of the track.

The elastic bridge possesses a period of vibration of its own. The result of synchronous, external periodic impulses will be to cause vibrations of cumulative amplitude, which will increase the fatigue of the members and may even lead to the destruction of the structure.

Reducing the phenomena to their greatest simplicity, the synchronous impulses are caused by :

1. Axle loads passing at a speed such that the period of vibration of the bridge is equal to double the time required for an axle to pass over the whole span of the bridge.

2. The excess balance for the horizontal balancing of the reciprocating parts of the locomotive mechanism.

The excess counterbalance weight gives rise to a centrifugal force proportional to the square of the speed of rotation of the axle, and the vertical sinusoidal of this force causes the load of the wheel on the rail to vary periodically. If the period of rotation of the axle is equal to the period of vibration of the bridge, the synchronous impulse will give rise to cumulative amplitudes, which will considerably increase the fatigue of the bridge.

In locomotives in which, owing to defective construction, the rotary parts are insufficiently balanced, the maximum

(1) Translated from the French.

(2) See *Bulletin of the Railway Congress*, July 1929, p. 859.

(3) See *Bulletin of the Railway Congress*, December 1929, p. 3129.

(4) See *Bulletin of the Railway Congress*, May 1929, p. 502.

(5) See *Bulletin of the Railway Congress*, December 1929, p. 3103.

load on the axle, or the relief of load on the axle, may become excessively great so that the axle is relieved completely of load, which is then applied suddenly to the rail. This effect, which in English-speaking countries has received the name of *hammerblow* is the origin of researches on impact.

The two effects of speed and balance weight are not synchronous and their maximum effects cannot be added together. Moreover, the results of calculations show that, as regards the *speed effect*, the speed at which there is synchronism with the period of vibration of the bridge far exceeds the maximum speeds at present allowed on railways.

As regards the balance weight effect, it must be observed — which hitherto has not been done — that it is not sufficient to establish the condition of synchronism for an *isolated axle*. This is an excessive simplification of the problem, which may lead to false results. In fact, the driving or coupled axles having free balance weights are grouped in 2, 3, 4, 5 axles. Their effects are combined and the resultant may be determined mathematically. With the aid of admissible hypotheses, the combination of the successive effects by Fresnel's rule shows that, for the ordinary grouping of 3 axles, the resultant is small if not zero, and that groups of 2, 4 or 5 axles may be likened in effect to 1 axle alone.

From this one would conclude that the locomotive with three coupled axles would be the least objectionable for the track, and that in the case of locomotives with more coupled axles, it would be advisable to concentrate the counterbalance weight for horizontal balancing in equal parts and arranged similarly on three adjacent axles.

This conclusion is important and builders should take it into consideration when dealing with the balancing of locomotives.

* * *

In fact, it must not be disguised that, although it may be interesting to simplify the problem in order to deduce practical conclusions, it is very complex in reality.

The locomotive is an elastic solid, the body of which is supported on springs. It is subjected to parasitic vibratory movements which may be studied by means of Herdner's theory of the elastic centre : vertical vibrations, pitching, rolling, hunting, having their own periods, and interfering with the main vibratory movements of the bridge. Moreover, these parasitic movements only come into effect if the passive resistances of friction are overcome. They may also modify the proper period of vibration of the bridge and disturb in consequence the synchronisms initially set up. A step forward has been made by the investigations carried out by Professor Inglis on the occasion of the English researches on impact (Report of the Bridge Stress Committee) by considering at least the influence of vertical vibration.

It still remains necessary to introduce the effects of all the movements of rotation about the axes of inertia of the system — pitching, rolling, etc.

Moreover, all the conclusions of synchronism suppose an exact determination of the proper period of vibration of the bridge. It is impossible to determine this exactly by calculation, even under well-determined conditions of load. During the passage of trains, the load is constantly varying. Nevertheless, if it is a matter of determining the period of vibration of the unloaded bridge, the Losenhausen apparatus or the apparatus used by the English Committee enables this determination to be made with sufficient exactitude.

* * *

If one wishes to consider the mathematical problem of impact fully for an isolated member of a bridge, for example, a diagonal of a lattice bridge, it is necessary to consider not merely the distur-

bances of loads giving rise to stresses, but also the elastic vibrations of the member. These vibrations are longitudinal and transversal and depend upon the joints at the ends of the member. The mathematical problem has not been solved, and the relative value of these results has not been determined; there is nothing to enable one to affirm « a priori » that they are negligible.

* * *

Apart from these elements of dynamic variations, which have their origin in a locomotive or vehicles assumed to be perfect, as well as in a bridge having known mathematical ties, it is necessary to consider the variations due to imperfections or defects in the vehicles, the track and the bridge.

The most marked defects as regards the vehicles are the flats on wheels, which result in considerable shocks. It is difficult to estimate this effect. which is not a common one.

As regards the track, the classical weak point is the joint, which likewise reacts by parasitic movements of the locomotive increasing the disturbance.

The English Committee has also considered the effect of rolling in loading one side only of the locomotive (rolling-lurching). We are of the opinion that it is also necessary to consider the successive variations of elasticity of the platform in the zone of the approach to the bridge — ordinary track on ballast — masonry of the abutments — track on the floor.

These successive modifications of elasticity cause parasitic vibrations of the body of the locomotive on its springs, resulting in variations in the loads on the wheels.

The state of the bridge and its structural constitution also have their influence on the dynamic disturbances. These effects have been brought to light by the Russian investigations (Streletzky, Rabinovitch). The investigators have attempted to deduce therefrom certain coefficients characterising the internal state of the bridge, its structural diagnosis as it were, and the service it is still capable of rendering.

* * *

The experimental results are innumerable but nebulous. No real concentration has been effected up to the present — there is not even a centre of attraction — the law of gravitation does not apply to them. The mechanical recording appliances employed in making the measurements have all the same defect, that they possess an inertia of their own with a frequency of vibration causing indeterminate parasitic vibrations in the diagrams. Lately electric appliances have been put to use (the electric telemeter of the Reichsbahn), based upon the variation in the electric resistance of a pile of graphite discs under variable compression. This idea was first applied by the Bureau of Standards of Washington, and the appliances were used in the American experiments on the test dam at Stevenson Creek.

The recording appliance employed by the English Committee was the Thomas electric appliance based on quite another principle — the electro-magnetic variations in a circuit with triode valves.

The experience gained with the electric telemeter is as yet insufficient to enable one to place absolute reliance on its results, but it is certainly the method of the future; serious investigations can only be brought to a successful issue by means of appliances the period of vibration of which cannot affect the results that are to be registered.

* * *

Restricting ourselves to a more modest horizon, the results obtained with simple apparatus, as well as the results of calculations, show that, in well-designed bridges, with modern engines, the dynamic variations do not attain the high values given by the formulæ.

In any event, it is not admissible merely to add maxima of different frequencies.

* * *

The use of the ordinary formulæ of the best known regulations — French formula — German formula — leads to results which do not differ much. There is some consolation to the embarrassed practician in using the formulæ of ignorance used by everybody else.

Is it necessary, as done by the English Regulations, to compile special tables of the loads for each span, taking into account the effect to the excess counter-balance weight almost exclusively? In our opinion, to do so is to complicate needlessly the applications, and by desiring to be too strict on one point, to run the risk of overlooking others of more importance.

In the present state of the researches, it is impossible to recommend any formula in comparison with the others — they must be used with judgment, and above all, care should be taken not to give them a too exact meaning.

With regard to the causes of impact, theoretical considerations and the experience gained indicate certain particular precautions to be observed:

1. Care should be taken that the treads of the wheel tyres are regular — flats capable of serious damage should be avoided.

2. Particular care should be paid to the upkeep of the track on the bridge floor and at the approaches.

Care should be taken that the joints of the rails are kept in order — if possible they should be placed off the bridge, at all events as close as possible to the supports. The trials of welding the joints on bridges will be followed with interest, this measure, if successful, being extremely favourable to the reduction of impact.

It is also advisable to strengthen the sections of the track at the approaches to bridges, so as to avoid rapid variations of the equilibrium of the locomotive on its springs.

3. The influence of the excess counter-balance weights of locomotives should be diminished by distributing the weights between groups of three adjacent coupled axles.

In addition to these conclusions of a practical character, it is obvious that one cannot but encourage the thorough researches of the Companies to help forward the investigation of the phenomena and the measurement of their maximum effects. At this limit, the problem becomes difficult and demands the collaboration of the most capable mathematical and technical knowledge. The remark will certainly be made that the bridges have stood up and still do so. The answer to this objection is that loads have never been as heavy or as fast as at the present; moreover, numerous examples could be given from actual practice, in which the introduction of greater speeds has given rise to fresh problems and has created the need for fresh solutions.

[625 .172 & 625 .174]

QUESTION IV.

(RECENT IMPROVEMENTS IN PERMANENT WAY TOOLS AND IN THE SCIENTIFIC ORGANISATION OF MAINTENANCE WORK).

(The special account will be found next to that on question XX).

SECTION II. — Locomotives and rolling stock.

[621 .132.8]

QUESTION V.

(LOCOMOTIVES OF NEW TYPES; IN PARTICULAR TURBINE LOCOMOTIVES AND INTERNAL COMBUSTION MOTOR LOCOMOTIVES) (1),

By Paul KOLLER,

Special Reporter.

Question V (Locomotives of new types) was dealt with in 5 reports :

No. 1, by Mr. Cossart, Chief Engineer of the Locomotive Works, French Nord Railway (2);

No. 2, by Mr. R. E. L. Maunsell, Chief Mechanical Engineer, Southern Railway (Great Britain) (3);

No. 3, by Mr. Paul Koller, Engineer, State Councillor and Assistant Director of the Czechoslovakian State Railways (4);

No. 4, by Mr. A. Lipetz, Consulting Engineer, American Locomotive Company, Schenectady, N. Y.; Non resident Professor, Purdue University, Lafayette, Indiana (5);

No. 5, by Professor Nordmann, Reichsbahnoberrat, Headquarters of the Deutsche Reichsbahn Gesellschaft (6).

The present report sums up reports Nos. 1, 2, 3 and 5 (7).

The efficiency of a steam locomotive of the usual type is small : about 8.5 % for simple expansion locomotives built since the war, with superheated steam at 320° to 350° C. (608 to 662° F.) and feed water heaters; between 9 and 10 % for the best locomotives of recent construction when the superheat is carried to about 400° C. (752° F.).

The overall efficiency of a steam locomotive may be taken as the product of three partial efficiencies, of which those of the boiler and motion are satisfactory in locomotives of the usual type. Therefore improvement in the efficiency of the motor has more particularly been sought after.

In practice to attain this end three different lines of development have been followed :

1. Condensing, long employed on stationary steam engines, has been used. However when the principles of condensing are applied the dimensions of the steam cylinders become excessive for the limited space possible on the locomotive. These principles therefore have led to the replacement of the piston engine by a steam turbine. The piston engine can also be kept for the higher pressures and the turbine merely used for the low pressures at which it works in a particularly satisfactory way.

2. High steam pressures have been in-

(1) Translated from the French.

(2) See *Bulletin of the Railway Congress*, November 1929 number, p. 2397.

(3) See *Bulletin of the Railway Congress*, September 1929 number, p. 1563.

(4) See *Bulletin of the Railway Congress*, April 1930 number, p. 1259.

(5) See *Bulletin of the Railway Congress*, March 1930 number, p. 863.

(6) See *Bulletin of the Railway Congress*, January 1930 number, p. 259.

(7) At the time this special account was drawn up, the translation of report No. 4, by Mr. Lipetz, was not available.

troduced (between 25 and 225 atm. (355 to 3 200 lb. per sq. inch) superheated to a high temperature [400 to 450° C. (752 to 842° F.)], and this has led to the classical type of locomotive being given up in favour of a water-tube boiler. At the same time it became necessary to adapt all the parts in contact with the steam to the high pressures and temperatures used.

It is obviously possible to combine the principles stated in 1) and 2) by using high pressures and condensing together.

3. The steam locomotive with its steam generator and steam engine has been replaced by the Diesel motor or some other similar type of motor of particularly high efficiency. The Diesel motor however requires a flexible transmission between the shaft of the motor and the driving wheels of the locomotive.

The locomotives of new types so far built or designed may consequently be divided into the following classes :

I. — Condensing locomotives, with the ordinary type of boiler.

A) Locomotives with turbines only;

B) Locomotives with steam piston engine and turbine combined.

II. — High pressure locomotives with a new type of boiler with water-tubes, and either :

A) Exhausting;

B) Condensing.

III. — Locomotives with internal combustion motors, or Diesel or other similar motors :

A) With electric transmission;

B) With hydraulic transmission;

C) With pneumatic transmission;

D) With mechanical transmission.

I. — Condensing locomotives, at low pressure (22 atm. [313 lb. per sq. inch] at the most).

Turbine locomotives with the usual type of boiler in conjunction with condensing have certain advantages and certain drawbacks as compared with the ordinary type of locomotive with direct exhaust.

The chief advantages are :

1. Maximum efficiency relatively high;

2. Continual use of the same pure distilled water (no scaling up of the boiler).

3. Uniform moment of rotation (smooth starting and running).

On the other hand the chief drawbacks are :

1. By suppressing the blast the automatic regulation of the draught and of the quantity of steam produced in the boiler in proportion to the speed of the locomotive is lost;

2. A great amount of more or less complicated auxiliary machinery is required, which takes up a lot of room and absorbs a considerable quantity of steam (18 to 33 % of the steam produced in the boiler);

3. As it is impossible to reverse the turbine a second turbine is required for reverse working or else a special transmission so that the engine can be reversed;

4. The turbine only attains its maximum power within very narrow limits of speed and at other speeds is less economical than the piston engine.

Among the turbine locomotives built in Europe up to the present, two chief types may be distinguished as far as the general arrangement of the different parts is concerned :

1. The Ljungström,

2. The Zoelly.

The Ljungström locomotive consists of two vehicles. The front vehicle carries an ordinary type of boiler, but fitted with an exhaust fan and an air pre-heater, both placed in the smoke box. The rear vehicle carries the main turbine with the transmission to the driving wheels, as well as a condensor directly cooled by the air, with the corresponding auxiliaries; this second vehicle is therefore the

real motor vehicle, as on the first the axles are carrying-axles only.

In the Zoelly design, the main turbine and transmission are placed at the end of the locomotive. The water-cooled condensor is also carried here immediately beside the turbine. The water cooler and its auxiliaries are however carried on the tender.

The following locomotives have been built up to the present :

A. — Locomotives with turbines only.

1. Ljungström type locomotives :

Four locomotives of this type have been built up to date.

a) A trial locomotive for the Swedish State Railways built in 1921 by Messrs. A. B. Ljungström Angturbin, of Stockholm, and Nydqvist and Holm, of Trollhattan, Sweden, which is no longer in service;

b) A narrow gauge locomotive for the Argentine State Railways using naphta for fuel, built by the same firms in 1925 and in use on the Argentine State Railways at the present time;

c) A second locomotive for the Swedish State Railways built by the same firm in 1926 and in use at present on the Swedish State Railways;

d) A locomotive built in 1926 by Beyer, Peacock and Co., Ltd. Gordon Foundry, Manchester, which has been tested on the London, Midland and Scottish Railway.

2. Zoelly type locomotives :

a) Trial locomotive built in 1921 by Esscher, Wyss and Co., at Zurich, and the Swiss Locomotive Works at Winterthur, now out of service;

b) Zoelly-Krupp locomotive built in 1924 by Messrs. F. Krupp, at Essen, Germany, for the German State Railways, and rebuilt after a number of trials; in service at the present on the Deutsche Reichsbahn;

c) Maffei locomotive built by the Maffei Company, Munich, Germany, in 1926, for the Reichsbahn; this is being reconstructed at the present time as a result of many experiments;

d) Belluzzo locomotive being built by Messrs. Breda, at Milan.

B. — Combined piston and turbine locomotives.

a) Trial locomotive built in 1926 by Henschel and Son, Cassel, Germany for the Reichsbahn (reconstructed from a passenger piston engine P8 type of the old Prussian State Railways).

The total maximum efficiency obtained up to the present with turbine locomotives is about 12 % (trials made by the Deutsche Reichsbahn with the Zoelly-Krupp locomotive). This result however was only obtained when running under steady conditions at a more or less constant speed of 80 km. (50 miles) per hour, the power developed on the tender draw bar hook being about 1 250 H. P. The maximum efficiency reported by the Ljungström Company is only 11.1 %.

The Henschel piston locomotive with a turbine motor driven tender is more powerful than the piston locomotive of the same kind without a tender motor by about 270 H. P. at a speed of 80 km. (50 miles) per hour.

Taking into consideration the fact that the steam turbine works at a small angular velocity in a much less economical way, and considering that the number of revolutions of a locomotive necessarily varies between zero and the maximum corresponding to the design of the locomotive, it will be seen that the advantage derived from the relatively higher maximum efficiency of the turbine locomotive can be notably reduced when starting and by reductions in speed on steep gradients. And this even more so by the fact that the auxiliaries, in part at least, have to work even while the regulator of the locomotive is shut.

On the other hand the construction of a turbine condensing locomotive is much more complicated, heavier and more

expensive (first cost price about 70 % higher) than the ordinary type of locomotive. In the same way upkeep expenses are notably higher.

Under these conditions the saving due to condensing would seem to be obtained at too great a cost. Before a definite opinion can be given comparative results obtained in actual working must be awaited. Up to the present the general benefit of the condensing turbine locomotive has not been proved. However it seems that this system could all the same be used advantageously in certain special cases (in countries where water is scarce; as locomotives for express trains making few stops).

II. — High pressure locomotives.

High pressure locomotives (between 25 and 225 atm. [355 to 3 200 lb. per sq. inch]) can have a notably higher maximum efficiency than ordinary type locomotives, especially if the principles of high pressure and high superheat are combined with condensing. In this last case however the advantage of a particularly high efficiency is achieved at the cost of the drawbacks already mentioned under (I).

If condensing be left out of consideration we can on the other hand retain the steam piston engine, the qualities of which are better able to give a satisfactory transport motor than those of the turbine. Further the advantage of the automatic regulation of the output of the boiler according to the speed of the locomotive by means of the exhaust blast is not lost.

In making use of high pressures and very high superheat temperatures however, a certain number of the present parts of the locomotive have to be replaced by new designs.

From this point of view, it is particularly necessary :

1. To build a new type of boiler, the walls of which must be protected against any accumulation of heat and which must at least equal in efficiency, flexibility, safety and mechanical strength the present form of locomotive boiler;

2. To adapt the steam engine to the great range of temperature and to the qualities of high pressure steam;

3. To adapt the different parts and auxiliary apparatus of the boiler and engine (e. g. the boiler casing, the packings, the feed water pumps, etc., etc.) to the high pressures and temperatures employed.

The pressures used vary within wide limits. The new London & North Eastern Railway locomotive has a pressure of 31.6 atm. (450 lb. per sq. inch); the Schmidt-Henschel, the Winterthur and the Krupp locomotives (turbines), 60 atm. (853 lb. per sq. inch); the Löffler-Schwartzkopff locomotive 120 atm. (1 706 lb. per sq. inch); the Benson-Maffei locomotive 225 atm. (3 200 lb. per sq. inch), [180 atm. (2 560 lb. per sq. inch) at the inlet to the turbine].

At present all the high pressure locomotives have water-tube boilers. The designs however differ very widely. There are lower and upper drums joined by water tubes (Winterthur); boilers based on marine practice (Krupp high pressure turbine locomotive); a cylindrical drum indirectly heated (high pressure Schmidt-Henschel boiler), or the more complicated Löffler and Benson systems.

In order to avoid the accumulation of heat in the walls of the high pressure boiler, and the damage that would result therefrom, the following are the chief precautions taken :

1. Use is made of purified feed water :

a) By the continual use of the same water : closed circuit of water and steam (high pressure part of the Löffler-Schwartzkopff locomotive and the condensing locomotives of Krupp and Benson-Maffei);

b) By treating the feed water before it passes into the high pressure boiler (by

passing through a special heater at a high temperature [about 250° C. (482° F.), Winterthur]; by passing it through a softener and a low pressure boiler (Schmidt-Henschel);

2. A good circulation of the water is assured, eventually — at particularly high pressures exceeding 100 atm. (1 422 lb. per sq. inch) — even of the steam enclosed in the high pressure boiler, and this by :

a) The natural feature of the difference in density between hot and cold water (Winterthur, heating boiler Schmidt-Henschel);

b) A pump which pumps back the heating steam (Löffler-Schwartzkopff);

3. Indirect heating can also be employed from the high pressure boiler :

a) By piping containing the heating steam (Schmidt-Henschel). In this case a heating boiler is needed with a higher pressure, which however can have a closed water and steam circuit and consequently be heated directly;

b) By introducing into the high pressure boiler a jet of superheated steam at the same pressure (Löffler-Schwartzkopff). In this case the superheater tubes are heated directly.

With high pressure steam, even when superheated, the limit of saturation is soon obtained during expansion. It is therefore opportune to superheat the steam again at the intermediate stages of expansion. With this object, superheated low pressure steam produced in a low pressure boiler is added (Schmidt-Henschel). In this system obviously part of the advantages of high pressures is lost by carrying out part of the work by steam produced in a low pressure boiler, i. e. under the same conditions as in an ordinary locomotive. New designs for this type of boiler for this reason greatly reduce the use made of the low pressure boiler.

In the Löffler-Schwartzkopff system only the *heat* obtained by the condensation of the high pressure steam, expanded to about 17 atm. (241.7 lb. per sq. inch) is used for heating the low pressure boiler. Therefore the heat is used in two ways, after the manner of compound locomotives, by using for carrying this heat, steam from two different sources. Even in this system therefore there are two distinct steam generators, one high pressure, the other low.

The principle of high pressure consequently results in certain complications in the construction of the locomotive. However these are much less than those involved by the principle of condensing. Nevertheless relatively simple designs will certainly be evolved. Even now valuable results can be obtained by fairly simple constructions, as is proved by the example of the Winterthur locomotive which has a single boiler and a simple expansion steam engine.

High pressure locomotives, already built or in course of construction are :

A. — Piston locomotives, exhausting to atmosphere.

1. Trial locomotive, Winterthur design, built in 1927 by the Swiss Company, at Winterthur, with a pressure of 60 atm. (853 lb. per sq. inch). This locomotive has undergone a series of trial runs on the Swiss Federal Railways and in Austria and France;

2. Trial locomotive, Schmidt-Henschel design, built in 1927 for the Deutsche Reichsbahn, which is in operation experimentally on the German lines;

3. Trial locomotive, Löffler design, with a pressure of 120 atm. (1 706 lb. per sq. inch) ordered by the Deutsche Reichsbahn from the Berliner Maschinenbau A. G. formerly L. Schwartzkopff. This locomotive has only just been completed.

4. London & North Eastern Railway locomotive with a pressure of 31.6 atm. (450 lb.) with four cylinders and com-

pound expansion which has just been put into working experimentally.

B. — Turbine condensing locomotives.

1. Trial locomotive ordered from Krupp by the Deutsche Reichsbahn; now being built;

2. Trial locomotive ordered from Maffei of Munich by the Deutsche Reichsbahn; still under construction.

Among high pressure locomotives those of the Sentinel type must also be mentioned. These are dealt with in Mr. Maunsell's report and have a lot in common with the same firm's rail motor coaches.

Up to the present the maximum overall efficiency reached by high pressure locomotives which have been tested (Winterthur, Schmidt-Henschel) is only 9 to 9.2 %, i. e. lower than that of the later locomotives of the ordinary type with high superheat. In comparison with less recent locomotives of the usual type of construction, when compared with that of new types of engines, the coal consumption of the high pressure locomotives is about 30 % lower.

The high pressure atmospheric exhaust locomotives which do not require complicated auxiliary apparatus would seem to be the type likely to result — once initial difficulties have been overcome — in a new locomotive with higher efficiency than that of the usual type while retaining its other precious qualities as an excellent transport motor.

III. — Diesel locomotives.

The efficiency of the Diesel locomotive is particularly high : 32 to 35 % of the energy contained in the fuel is available at the motor shaft. From these figures however a deduction must be made not only of the losses between the motor shaft and the locomotive draw bar hook which can be 10 % or more, but above all account must be taken of the fact that the cost of the unit of heat energy in the naphta is much higher (in Germany about 2 1/2 times as high) as the cost of the unit of heat energy obtained by burning coal.

To compare the efficiency of a locomotive using coal with that of one burning fuel oil, the efficiency of this latter must be reduced in proportion to the higher cost of fuel.

Not only does the Diesel motor, as developed already, require certain auxiliary equipment (source of energy for starting, etc.) but furthermore its characteristics, especially its small range makes it impossible to use it on a locomotive without certain supplementary apparatus (water-coolers, etc.) and in particular without some flexible coupling giving a few degrees movement, between the motor shaft and the driving wheels of the locomotive.

For this reason the construction of a Diesel locomotive becomes more complicated, heavier and more expensive (by 50 to 100 %) than that of a steam locomotive of the usual type.

Nevertheless Diesel motors are used on railway vehicles in many cases already. Most of these are on rail motor coaches but all the same the number of Diesel locomotives, usually with electrical transmission, is quite large (for example the locomotives of the Tunisian Railway Company, the Danish State Railways, certain Swedish Railways, etc.).

Even moderately powerful (about 500 H. P.) Diesel locomotives have been built as for example the Ansaldo locomotive of the Italian State Railways.

What particularly interests us here are the large Diesel locomotives which can draw the trains worked today on the chief railways. Among such may be considered the following Diesel locomotives :

A. — *Diesel-electric locomotives.*

Electrical transmission which is perfectly flexible fits these locomotives for widely different railway services, even for shunting operations.

1. *Diesel locomotives with electrical*

transmission, for goods services, No. 001 of the Soviet Railways, built in 1924 from the designs of Professor Lomonosov by the Maschinenfabrik, Esslingen, Germany. The Diesel motor was supplied by the Machinenfabrik Augsburg-Nürnberg Company (M. A. N.); it has a maximum power of 1 200 H. P. This locomotive has undergone many trials; since 1925 it has been in service on the Soviet Railways.

2. *Diesel electric locomotive, for goods services of* the London & North Eastern Railway, under construction, will be achieved by the transformation of an electric locomotive. This locomotive will have a Beardmore variable speed Diesel motor of 1 000 H. P.

3. *Diesel electric locomotive of the Japanese State Railways,* 1C1 type, under construction in Germany in the Esslingen shops. The Diesel motor will be supplied by the M. A. N.

B. — *Diesel locomotives with hydraulic transmission.*

This method of transmission has been chiefly studied in England, Germany, Austria and Sweden; but the results have not come up to expectation. The efficiency of hydraulic transmission was not good enough and losses between the piston of the motor and the locomotive draw bar hook were 58 % of the indicated power. Only a few locomotives have been made by way of experiment and were of medium power, 400 to 500 H. P. at the most.

C. — *Diesel locomotives with pneumatic transmission.*

Pneumatic transmission has certain advantages. First of all, it enables the heat of the combustion gas and the cooling water to be used to reheat the working medium and so to increase the thermal output of the engine. On the other hand this kind of transmission presents many difficulties which have not yet been finally solved. Different systems have been designed (in Germany the Görlitzer M. F. system, the Zarlatti and Cristiani systems in Italy, etc.) and several trial locomotives have been built, of small and medium size.

The only large locomotive of this type has just been built in Germany.

1. *Diesel locomotive with pneumatic transmission of the German State Railways.* — The passenger locomotive, of the 2-C-2 type, was ordered in 1924 from the Esslingen shops, Germany. The Diesel motor is of M. A. N. construction; its normal power is 1 000 H. P.

This locomotive works with compressed air at 7 atm. (100 lb. per sq. inch), superheated by the heat of the exhaust gas to about 320° C. (608° F.).

Trials have been made which show that at this relatively low pressure it is possible to use air as the working medium without any fear of oil deposit or even of explosions of the lubricant.

It is easy to start up this type of Diesel locomotive and the compressor can be run before moving the locomotive itself.

D. — *Diesel locomotives with mechanical transmission.*

1. *Diesel locomotive with mechanical transmission for goods services, No. 005 of the Soviet Railways.* — This locomotive of the 1E2 type with a maximum power of 1 200 H. P. on the motor shaft was built, in 1926, from the designs of Professor Lomonosov, by the firm of Hohenzollern, at Dusseldorf. After having undergone numerous trials this locomotive is now working regularly on the Soviet Railways.

This locomotive with mechanical transmission has given the maximum total efficiency of any Diesel locomotive, i. e. 29.4 %. The efficiency of the Diesel-electric locomotive is a little lower, about 25 %. It is hoped to get the same efficiency from the Deutsche Reichsbahn

Diesel locomotive with pneumatic transmission.

Even when account is taken of the cost per unit of energy, the output of the Diesel locomotive is slightly greater than that of the best steam locomotives of the usual type. Making allowances for the Diesel locomotive, the results are still more favourable.

The cost price of a Diesel locomotive is always notably higher, the construction heavier and more complicated, which has an unfavourable effect on the purchase price as well as on upkeep expenses.

The chief advantage of the Diesel is its high efficiency; this however depends upon the cost of fuel.

The future development of these locomotives must be awaited, as those that have been built up to the present are only « laboratories on wheels » according to a remark of Prof. Lomonosov, the chief introducer of this method of traction.

CONCLUSIONS.

During the last ten years in the different European countries, especially England, Germany, Italy, Sweden, Switzerland and Soviet Russia many efforts have been made to develop a new type of locomotive for using in a more efficacious way the heat energy of the fuel.

A certain number of condensing steam locomotives as well as high pressure locomotives and Diesel locomotives have been built and undergone trials. These trials have shown that certain initial difficulties are still to be overcome, usually fairly important ones, before any satisfactory construction can be arrived at. For this reason we are still at an experimental stage and up to the present the definitive type of the locomotive of the future has not been designed.

Nevertheless new paths have been opened up. The large amount of preparatory work already carried through, and the experience already obtained will make it possible to realise — perhaps sooner than is generally expected — a new type of locomotive.

Two of the reports presented to the Congress have drawn attention to the fact that such a development would be largely facilitated in Europe by the existence of scientific experimental stations for testing railway rolling stock.

Taking into consideration the state of affairs which has been described I propose for acceptance the following recommendations :

The Congress recommends the Administrations represented here :

1. To encourage efforts to create a new type of locomotive, by facilitating in particular the initiative of locomotive builders in this matter.

2. To carry out methodically trials of locomotives of new types, of different designs, built by different makers and to publish the results of such trials systematically and as made.

3. To study the question of the opportunity and possibility of creating in Europe an international experimental station for scientific experiments on railway rolling stock.

[621 .154]

QUESTION VI.

(IMPROVEMENTS IN THE STEAM LOCOMOTIVE) (1),

By R. P. WAGNER,
Special Reporter.

The aim of this report is to present a summary of the views expressed concerning Question VI : « Improvements in the steam locomotive » in the separate reports which have already been published in the monthly *Bulletin*. This summary takes into account the following five reports which have been made, on the respective territories named, by Messrs. :

1. Lentz (New York Central Railroad) for America (2);

2. Gresley (London & North Eastern Railway) for the British Empire, China and Japan (3);

3. Parmantier (Paris, Lyons & Mediterranean Railway) for France, Italy, Portugal, Spain and their Colonies (4);

4. Bals (Rumanian State Railways) for all other countries except Germany (5);

5. Wagner (Deutsche Reichsbahn Gesellschaft [German State Railway Company]) for Germany (6).

To facilitate reference to the matter, illustrations and tables, the sequence of the questionnaire has been followed generally, but as might be expected in a summarising report, there is some deviation from this plan when dealing with the various details.

I. — Increase of steam pressure.

In the use of higher pressures for boilers of the usual design, there is a fundamental difference between the American Railways, reported on by Mr. Lentz, and those of the other countries.

The U. S. A. are incorporating high pressures in their standard designs on a large scale. Ever since 1922, practically all new boilers have been constructed for 14.7 to 17.6 at. (210 to 250 lb. per sq. inch). More than 1 500 locomotives are for pressures of 15.8 at. (225 lb. per sq. inch) and upwards, and more than 50 for pressures of 18.6 to 20 at. (265 to 284 lb. per sq. inch). The main reason, according to Mr. Lentz, for the raising of boiler pressures is the prevalence in America of a limited cut-off. Nevertheless locomotives not working with a limited cut-off are now employing boiler pressures from 15.8 to 16.9 at. (225 to 240 lb. per sq. inch). No doubt the high wheel loading permissible in America has also played an important part in this development, since this permits greater latitude in regard to increasing the weight of the boiler.

In other countries the steam pressure employed in locomotives built since 1922 has not as a rule exceeded 12 to 14 at. (170.6 to 199.1 lb. per sq. inch) for

(1) Translated from the German.

(2) See *Bulletin of the Railway Congress*, October 1929 number, p. 2113.

(3) See *Bulletin of the Railway Congress*, November 1929 number, p. 2689.

(4) See *Bulletin of the Railway Congress*, September 1929 number, p. 1573.

(5) See *Bulletin of the Railway Congress*, November 1929 number, p. 2421.

(6) See *Bulletin of the Railway Congress*, January 1930 number, p. 99.

simple expansion and 14 to 16 at. (199.1 to 227.6 lb. per sq. inch) for compound expansion. As yet only a few railways have complete series of engines in service with higher boiler pressures; examples of these are :

— The Rumanian State Railways — 65 locomotives of American manufacture, with simple expansion, have a steam pressure of 15 at. (213.3 lb. per sq. inch).

— The Deutsche Reichsbahn — 75 locomotives with simple expansion, series 01 (4-6-2), use 16 at. (227.6 lb. per sq. inch).

Practically all railways appear to aim at increasing the pressure while retaining boilers of the usual type. Several railways have already put into regular service special experimental designs of boilers for higher pressures, in which there is no basic change in the method of construction; this is with the object of investigating the economies that can be obtained by increase of pressure, the behaviour in service and the maintenance required.

Where the same constructional materials are used as hitherto, the increase of pressure on most railways is limited to about 16 at. (227.6 lb. per sq. inch), since the maximum wheel load permissible does not allow a further advance in the weight of the boiler; it would appear that the expedient of increasing the pressure from 16 to 20 at. (227.6 to 284 lb. per sq. inch) without strengthening of the boiler plates mentioned in Mr. Parmantier's report is only possible when special care is taken in manufacture. The experience by the French Est Railway with a 4-6-0 superheater compound engine of this kind that has been working since April 1926, has so far been satisfactory.

The success attained by the use of higher pressures and the experiences in service and maintenance have been reported on by several railways, but there is some lack of consistency on several points.

— Mr. Lentz mentions the following advantages :

1. The possibility of developing more powerful locomotives whilst reducing the weight per unit of output.

2. Steam economy.

The cost of maintenance during the past three years is stated to have been satisfactory, although it is indicated that a final decision can only be come to at the end of a further experimental period.

— Italy reports : Increasing the pressure from 12 to 16 at. (170.7 to 227.6 lb. per sq. inch) on a 2-6-2 superheater engine with simple expansion resulted in an increased tractive power of 5 % and a fuel economy of 5 %.

— On the Deutsche Reichsbahn it was found that when the pressure was reduced occasionally from 14 to 12 at. (199.1 to 170.7 lb. per sq. inch) on engines of old design with simple expansion, the consumption of fuel increased by 5 to 7 %. Comparative experiments with two precisely similar engines of the new standard design, series 01 (4-6-2) using 16 and 14 at. (227.6 and 199.1 lb. per sq. inch) showed that on considerable loads [1 000-2 400 H. P. (indicated)], the engine working at a higher pressure effected an economy in heat consumption of 3 to 5 %.

— The conclusion arrived at by Mr. Gresley upon the basis of experiments carried out on the London and North Eastern Railway with fifteen locomotives fitted with boilers for 15.5 at. (220 lb. per sq. inch) instead of the original 12.7 at. (180 lb. per sq. inch), is that the advantages of the higher pressure are neutralised by the increased cost of maintenance.

The situation may be summarised by saying that all the reporters have testified to the economy in fuel consumption, but that sufficient experience is still

lacking upon which to base an opinion as to how the costs of maintenance are affected. It appears probable that these costs can be kept within the same limits as previously, provided the greatest care is taken in the manufacture of the boilers and certain constructional features are employed, such as those referred to in the German report.

As far as can be seen, a further increase of boiler pressure above 16 or 20 at. (227.6 to 284 lb. per sq. inch) will be possible only if special alloy steels are used. Experimental work in this direction is proceeding in America. The Canadian Pacific Railway is using silicon steel on 52 boilers for 17.8 at. (250 lb. per sq. inch) and nickel steel on 44 boilers for the same pressure. The Delaware & Hudson Company has an experimental locomotive for some 22 at. (313 lb. per sq. inch) with a stay-bolt type of fire-box. The Deutsche Reichsbahn is now considering the idea of building two locomotives for 25 at. (356 lb. per sq. inch) with boilers of normal type provided with corrugated stay-bolt fire-boxes constructed of a special material made by Messrs. Krupp. Such a pressure appears to be the limit at the moment for boilers of the usual type. What the life of these boilers will be is a question which must await the results of the tests.

II. — Steam superheating.

1. *Increase in the degree of superheat.*

A general inclination is shown to raise the superheat temperature for the reason that this is discerned to be the simplest method of achieving economy. Whereas a few years ago the temperature aimed at with normal boiler pressures was still 350° C. (662° F.), the corresponding figure at the present day on most lines may be said to be 380 to 400° C. (716 to 752° F.). Thanks to the lubricating apparatus and oils now available it is possible to deal with the lubrication of piston valves and cylinders at these temperatures; on the other hand, even with simple expansion, any loss in the cylinders due to incomplete utilisation of the heat content of the steam is more than counterbalanced by a considerable gain arising from the increased volume of the steam.

Only a few railways, as in Czecho-Slovakia, Poland and Sweden, where the superheat now used, even on new engines, is considerably lower than 350° C., are satisfied to restrict themselves in the immediate future to 350-360° C. (662 to 680° F.).

Reference must be made to the view adopted by the Paris-Orleans Railway (Mr. Parmantier's report) that it is not desirable to exceed 350 C°. with simple expansion, owing to the fear of loss due to the exhaust steam being superheated. As against this, the German report gives experimental results which show that on the new standard engines of the Reichsbahn, considerable savings in heat consumption are realised, in spite of the exhaust steam being superheated. As these experiments are affected by other constructional features, it is quite possible that the results obtained by the Paris-Orleans Railway would be confirmed if the superheat of locomotives of old type were increased to 400° C. (752° F.).

Mr. Gresley cites an outstanding case of departure from the usual practice; the London, Midland & Scottish Railway had in service 200 oil-fired locomotives which worked with 440° C. (824° F.) of superheat. Once initial difficulties with stuffing-box packing had been overcome, no further troubles were experienced.

2. *Improvements in superheaters and the details connected with superheating.*

Until a few years ago there were difficulties in attaining the temperature required in the superheater. These may now be considered as having been over-

come. According to the reports of Messrs. Bals, Parmantier and Wagner, the methods of calculation used hitherto for determining the superheater dimensions cannot be regarded as altogether adequate; it is recognised as the result of calculations and tests that the desired end can be approached more satisfactorily by increasing the quantity of heat in the superheater tubes rather than relying only upon an increase in the heating surface of the superheater. The increased quantity of heat is obtained by modifying the ratio between the cross-sections of the superheater tubes and fire tubes, may be, by using superheater tubes of larger diameter, fire tubes of smaller diameter, the introduction of baffle rings into the fire tubes, or altering the construction of the parts which support the superheater elements. By stating the most important features of design in superheaters which have shown good results, the reporters have furnished a means of forecasting dimensions which will realise the modern conception of a better distribution of heat between the superheater tubes and the fire tubes.

Many railways have made experiments in the direction of substituting other designs for the normal Schmidt type of superheater. As a rule the changes are in the direction of employing other forms of tube elements with a view to obtaining better transference of heat between the flue gases and the steam. Such good results have been obtained on the French Est Railway with the DM element that all their new locomotives are now being equipped with it. The Deutsche Reichsbahn uses the Wagner type of superheater for boilers of large output; so far the results in service can be considered satisfactory. Generally speaking, however, the use of plain circular tubes has been retained, and the particular arrangements used in various countries differ only in the disposition of the elements, the distance of the return bends from the tube plate at the fire-box end, the distance of the front return loops from the front tube plate, and in the construction of the superheater headers. The latter are in any case now designed more and more as separate headers for saturated and superheated steam.

The Schmidt small-tube superheater type E has found extensive favour in America; its special constructional features are as follows :

The whole of the available portion of the tube plates is utilised for superheater tubes of 3" to 3 1/2" diameter into which the elements of 1 1/8" or 1 3/16" diameter tube project. Each individual element consists of two tubes (a loop), and each pair or three of these elements are joined to a connecting piece which in turn is fixed to the header. A point worthy of mention is that more than 1 000 locomotives are fitted with multiple regulator valves between the superheater and the valve chest; these regulator valves will be referred to later. In these cases the smoke box is provided with an opening and easily removable cover over the superheater header for the purpose of giving access to the superheater and regulator valves, if it is desired to examine them or make small adjustments. Type E superheaters have already been fitted to more than 1 800 engines.

Mr. Lentz gives the following testimony in his report :

— The curves which are appended for the steam consumption per unit of output for engines with the old type A superheater (the ordinary large-tube superheater), and with the new type E small-tube superheater, show a saving in fuel of 8 to 12 %. At the same time the tractive power at the limiting output of the boiler is considerably increased while the better heat utilisation results in a reduced weight of locomotive.

— For boilers working at high pressures, the type E superheater has the special advantage of avoiding an increase of

weight, and, it is also claimed, prevents the formation of scale as a consequence of the improved water circulation.

— This superheater is particularly welcome as a means of increasing the superheater surface in boilers of considerable output in which the evaporation surface has a high specific output and the steam enters the superheater with, say, 5 % wetness.

It should be noted, however, that in long boilers the type E superheater necessarily gives rise to considerable resistance to the flow of the flue gases through the tubes. Hence, any figures which are given for the resulting economy represent the difference between the heat saving due to the higher superheating, and the increased heat consumption in the cylinders caused by the greater back pressure from the blast pipe.

The use of dampers for the protection of the superheater has, with a few exceptions, been given up; this has not given rise to any troubles. Nevertheless, Messrs. Parmantier and Bals report that some railways have made provision for cooling the elements when the engine is running with the regulator closed. Air inlet valves, which are partly automatic and partly air-controlled, are provided on the saturated steam side of the superheater chamber so that a stream of cooling air is drawn through the superheater by the cylinders. One administration (the Belgian National Railway Company) has arranged the air valves so that a fine jet of live steam can be injected; this is said to improve the air circulation and also to ensure the retention of the film of lubricating oil in the cylinders. The Paris-Orleans Railway sprays water on to the superheater, while other French railways keep the throttle slightly open so that a film of steam is maintained in the cylinders. Mr. Lentz reports that on engines fitted with multiple throttles, superheated steam is used for all the auxiliaries, so that in this case there is always a flow of steam through the superheater to keep it cool.

In addition, there is the device adopted on many American locomotives of injecting idling steam into the steam pipe on both sides of the superheater with the object of keeping the cylinder lubricated.

3. *Pyrometers for superheated steam.*

Many railways have given up fitting pyrometers on every engine for the reason that they do not offer any particular benefits to compensate for the considerable maintenance outlay.

The reporters make the following statements on this subject :

— Mr. Gresley reports that they are used only for experimental purposes.

— In the countries covered by Mr. Parmantier's report pyrometers are still largely used, but the French Est and Nord Railways are inclined to give them up, although only in the case of freight locomotives with regard to the last-mentioned line.

— Mr. Bals reports that the Guillaume-Luxembourg does not use any pyrometers; in Bulgaria, on the other hand, every engine is so equipped, whilst Poland employs them only on passenger and express locomotives.

— All the engines of the Deutsche Reichsbahn are fitted with pyrometers as they are considered the best means of helping the crew to avoid bad firing and to work the locomotive economically.

So far there is little uniformity in this matter, but it is worthy of note that it has proved practicable to work with superheated steam without using pyrometers.

It is not proposed to deal with the question of the most suitable type of pyrometer, since none of the reporters has indicated any clear preference for one or other of the established systems.

4. Lubrication of valves and pistons.

The reports indicate that the initial difficulties met with when the superheat temperature was increased, have to a large extent been overcome. The quality of the oil used in contact with the hot steam, and the development of lubricating devices and valve bodies on sound lines, are closely related matters. First of all, a brief survey of the reporters' views concerning lubricating oil :

— Mr. Lentz does not make any reference to the lubrication of superheater locomotives; it may be legitimately assumed that no difficulties are now experienced on the lines which he represents.

— Mr. Gresley again sees no difficulties in lubrication at temperatures up to 415° C. (779° F.).

— Mr. Bals reports that generally speaking the oils that are used give satisfaction, except in the case of Norway, Denmark and the Guillaume-Luxembourg, who are not quite satisfied.

— Mr. Parmantier states that on the Alsace-Lorraine lines, the French Nord and the Paris-Lyons-Mediterranean Railways, sooty deposits are experienced in the steam passages at temperatures of 400° C. (752° F.). Otherwise the railways are satisfied with the particular oils employed, of which the properties are given.

— According to the German report, difficulties are no longer experienced by the Reichsbahn in regard to the properties of the lubricating oil. Attention is drawn to the relation between the vaporisation temperature and the flash point, as the vaporisation temperature is the factor which influences the retention of the oil on the cylinder walls. The oil used by the German Reichsbahn has a vaporisation point of over 400° C. (752° F.) at the pressure ruling in the valve chest.

With regard to the most satisfactory design of lubricator, Mr. Bals is in agreement with the German Reichsbahn that a mechanical lubricator is preferable to a condensation (sight-feed) lubricator. Mr. Parmantier gives information on some tests made by the French Est Railway with improved lubricators of both types, which showed that there was nothing to choose between the two systems. But nevertheless, the figures given in his summary of the types of lubricators in use, indicate the leading position of the mechanical lubricator.

For ensuring at all times, even at the moment just after the regulator is opened, that the lubrication is adequate, oil check valves are now universally fitted in the oil pipes close to the cylinders; they not only prevent the oil running out of the pipes, but also preclude steam and air from entering the oil pipes. The reporters give drawings of oil check valves which have given satisfactory results. The German report gives 200 at. (2 845 lb. per sq. inch) as the pressure against which the oil pump must be able to continue to function in order to ensure safe lubrication in the event of the oiling openings becoming dirty or encrusted.

According to Mr. Bals' report, some administrations have introduced atomisers for the purpose of spraying the oil on to the surfaces to be lubricated in a finely divided form by means of steam; this may be effected either by atomising valves fitted at the lubrication points or even by connecting the oil feed pipe into the steam pipe before the latter enters the valve chest so that the steam strikes the oil and carries it along in a finely divided form. In America the use of an atomising arrangement is the prevailing practice.

A number of railways are still experimenting with oil emulsions or the addition of graphite, but no definite conclusions or news of the general introduction of either of these has been reported by any line.

No uniformity exists with regard to the number of lubricating points. On some lines the valves only are lubricated, on others the valves and high pressure cylinder, and on a third group the high pressure cylinders only; in other cases the high and low pressure valves and cylinders.

The reports show, therefore, that satisfactory cylinder lubrication can be achieved by several equally good methods.

5. *Valves.*

No new forms of constructing piston valves are to be noted. Only a few lines are still using wide spring rings, whereas the adoption of narrow rings only 6-7 mm (15/64-9/32 inch) wide is practically universal. The German report states that wide rings have been found unsuitable, since they could only be used with very liberal lubrication and up to 300° C. (572° F.) superheat, under which conditions bad over-lubrication and encrustation had to be faced. It may be mentioned that the Deutsche Reichsbahn uses only two sizes of valve on their standard engines, 220 mm. (7 7/8 inches) diameter for cylinders of less than 500 mm. (19 11/16 inches) diameter, and 300 mm. (11 13/16 inches) diameter for larger cylinders. The larger size of valve gives a better utilisation of the available cylinder volume without the necessity of running with late cut-offs.

6. *Packings for valve rods and piston rods.*

The Schmidt and similar types of soft metal packing which were introduced when superheated steam came into use, are still used extensively at the present day in conjunction with various metallic compositions for the packing rings. Nevertheless, as the degree of superheat was raised, many railways were no longer satisfied with packing of that kind. Improvement was sought by modifying the metal composition so as to obtain a more heat resistant material, or by doing away with soft metal altogether and developing a box type of packing gland with cast-metal rings in which surface packing and labyrinth packing are combined. A number of railways have gone over to these glands entirely or are on the point of introducing them.

— Mr. Bals reports that the Czecho-Slovakian Railways use Huhn & Hauber glands on locomotives with tail rods to the pistons with very good results; they are said to run 36 000 to 42 000 km. (22 370 to 26 100 miles). The remaining lines use either soft metal packings of the Schmidt type (Sweden, Norway, Rumania, Holland, the Guillaume-Luxembourg Railways) or soft metal packings of other types (Belgian National Railways and Swiss Federal Railways). These railways are mostly still at the experimental stage so far as the use of cast-iron packing glands is concerned.

— Mr. Parmantier similarly reports that soft metal packings are still used extensively, but that recently satisfactory tests having been made with cast-iron glands; some railways are proposing to equip their locomotives with this type. The Paris-Orleans Lines are going to employ Hauber packing and the French Est Railway a type of their own; the latter has given a life of about 60 000 km. (37 300 miles).

— The Deutsche Reichsbahn fits all its engines with a cast-iron stuffing box which has been evolved by combining the best features of four different types. Only three sizes are required for new locomotives since the piston rod is of the same diameter on both sides of the piston, and only three sizes of piston rods are manufactured, viz. 80,100 and 110 mm. (3 5/32, 3 15/16 and 4 3/8 inches) diameter. These glands often run for two to four years without needing attention of any kind.

It may be assumed that with the gene-

ral adoption of higher superheat the box-type of gland with cast metal rings of iron or bronze will come into general use, and difficulties in keeping valve and piston rods tight will entirely disappear.

7. Relief valves. — Snifting valves. — Bye-pass valves.

It appears from the reports that it is now general practice to fit relief valves to the cylinders of locomotives having piston valves.

There is not at present any general agreement as to whether it is more expedient to fit snifting valves or bye-hass valves, or both. Actually, these three arrangements are found in practice: Bye-pass valves only are used on the Aragon Railways, in the new standard designs of the Deutsche Reichsbahn and on the Paris-Lyons & Mediterranean Lines; snifting valves only on the French Est and Nord, and on some 90 engines of American construction on the Rumanian State Railways. No information is available concerning America and England. Most of the other railways continue to fit both bye-pass valves and snifting valves. Mr. Bals is of the opinion that a locomotive runs better if both are provided. As against this, a disadvantage of fitting snifting valves is that with increasing superheat and the resulting higher temperature of the cylinder walls, there is a danger of the oil burning when air is admitted following the shutting of the regulator. Mr. Gresley lays stress on this point and Mr. Parmantier reports that on the Paris-Orleans the occurrence of incrustation has been confirmed when using superheat of more than 350° C. (662° F.) on locomotives fitted with snifting valves.

The plan of fixing the snifting valve on the valve chest has been given up in many cases. On the Czecho-Slovakian and Belgian Lines and the Swedish Bergslagen Line it is located on the wet steam side of the superheater chamber for the purpose that has been mentioned earlier, of securing a stream of cooling air for the benefit of the latter.

There is no doubt that the bye-pass valve is a necessary evil from the point of view of the simplicity of the locomotive. In this connection Mr. Parmantier's reference to the Troffinoff valve is of interest since, if this proves satisfactory, it will be possible to do away with both bye-pass valves and snifting valves. The Deutsche Reichsbahn also has further experimental work in hand on similar bye-pass piston valves. All valves of this type have as a common feature a spring which is in the steam space and inaccessible for continuous observation; whether this will work satisfactorily in practice remains to be confirmed.

III. — Feed water heating.

1. Present position regarding the adoption of feed heaters.

The reports are unanimous that feed water heating presents one of the best methods of raising the economy of the steam locomotive. On the one hand fuel and water consumptions can be reduced, and on the other hand it is possible to obtain a larger output for the same weight, while at the same time the maintenance charges can be diminished. Consequently the number of feed heaters installed, is already considerable. Not only do most railways include them on new engines, but they are also being fitted to the majority of existing locomotives. The figures given in the several reports for the number of heaters in use are as follows : — Mr. Bals, 1865; Mr. Gresley about 5 300; Mr. Lentz, 6 120; Mr. Parmantier, 4 326, inclusive of the construction planned for 1928; the Deutsche Reichsbahn about 15 000. Unfortunately, all the reporters have not given the total number of locomotives, so that it is not possible to as-

certain in every case the proportion of engines that is equipped with feed water heaters. In the case of the Deutsche Reichsbahn, it is about 65 %; in the countries dealt with by Mr. Bals, about 13.5 %, and for the railways covered by Mr. Parmantier's report, about 12.5 %.

Several kinds of feed heaters are in use. Exhaust steam injectors, surface heaters, and contact heaters. According to the reporters, the distribution of the various types is approximately as follows :

—	Bals.	Gresley.	Lentz.	Parmantier.	Wagner.
Exhaust steam injectors . .	1 489	3 374	620	497	Several under test.
Surface heaters	327	1 260	5 500	929 (*)	15 000
Contact heaters	43	646		2 000	—
Total . . .	1 859	5 280	6 120	3 426	15 000

(*) Including 739 German-built engines.

According to these figures and disregarding America and the German Reichsbahn (Mr. Lentz does not give the number of surface and contact heaters separately), exhaust steam injectors and contact heaters have been used much more extensively than feed heaters of the surface type. The railways represented by Mr. Bals and Mr. Gresley prefer the exhaust steam injector, whereas those covered by Mr. Parmantier's report use more contact heaters.

The following table shows the distribution of the principal makes :

Exhaust steam injectors.		Surface heaters.		Contact heaters.	
Davies & Metcalfe	4 279	Knorr.	16 060	ACFI/RM.	1 183
Friedmann	1 039	Elesco.	357	Dabeg.	266
		CCP.	...	Worthington.	496
		Improved ACFI.	190	Weir.	54
		Weir.	67	..	...
		Various Japanese.	746	...	...

It is not possible to refer here at length to flue gas feed water heaters or the tests which have been undertaken on some lines with heaters of the most varied types; reference will be made only to the usual types mentioned above.

2. *Information on the operation of and results obtained with feed water heaters.*

The view of the reporters is that most types lend themselves to ease of operation. It appears that the exhaust steam injectors require somewhat more attention if the desired economies are to be realised, the reason being that in this case the admission of live steam occurs automatically when the locomotive is idle. It is quite sufficient to observe the water level (or where pumps are fitted, to observe the pulsation indicator which is usually connected in the delivery pipe) in order to make sure that the feed arrangements are working properly. The pyrometer and thermometer have not proved satisfactory in continuous service on account of their being rather delicate; they are not considered necessary and it is suggested that they should only be installed occasionally for the purpose of controlling the method of operating the feed heater.

The temperature attained by the feed water varies from 80° to 100° C. (176 to 212° F.) According to the particulars given by Mr. Bals and Mr. Gresley, higher temperatures are obtained with the ACFI/RM type than with other designs.

There is agreement that the steam consumption with surface as well as with contact feed heaters is about 2 to 3 %.

The figures given for the saving in fuel on regular service cover a very wide range varying between 2.5 and 12 %, so that it is impossible to present a clear picture. The saving certainly depends very largely on the service schedule to which the particular locomotives are worked, and it is only natural that the best results and the greatest economies are achieved by engines operating on long runs with few stops. The following table gives a summary of the percentage saving in fuel :

Reporter.	Exhaust. steam *Friedmann.*	Injectors *Metcalfe.*	Surface heaters. *Knorr.*	Contact heaters.		
				ACFI/RM.	*Dabeg.*	*Worthington*
Bals	5-12	5-12	8-12	9-12	12	5-12
Gresley . . .	...	2 1/2-4. On one line 8.	...	8-10	...	...
Parmantier .	...	5-6	8-10	...	...	7-12

Even though no conclusive figure for the saving of fuel is given, nevertheless the reports agree that generally speaking all the approved types save their cost in 3 to 4 years, and it appears desirable to extend their use. This holds good also for the exhaust steam injectors of the Metcalfe and Friedmann patterns for which a smaller fuel economy is given by Mr. Parmantier and Mr. Gresley than for the other types, but in respect of which the first cost and maintenance charges are lower.

The saving of water is given as 10 to 15 %, depending upon whether the exhaust steam mixes with the feed water, whether the water of condensation is led back from the heater to the tender or the

suction pipe, or whether the water of condensation is allowed to go to waste on to the track.

Mr. Lentz reports on some special tests which were carried out to ascertain what increase of evaporation could be obtained on a particular boiler with the same grate loading. It appeared that the actual evaporation was greater than could have been anticipated from previous calculation (an increase of 20.6 % as compared with 15 %). Some comparative tests between two boilers are also of interest; both were constructed for an evaporation of 22 700 kgr. (50 000 lb. per hour) at the same grate loading, one with and the other without a feed heater. In this case the actual evaporation and the efficiency attained far exceeded the predetermined values.

The degree of superheat does not fall in every case, and even when it does the amount is small. Mr. Bals and Mr. Parmantier agree on a figure of about 10° C. (18° F.). A small reduction of back-pressure occurs in the blast pipe since the volume of steam discharged is of course reduced. No difficulties are experienced in adding feed heaters later since for the same duty the boiler has less evaporation to perform and consequently less fuel to burn. No special recommendations are made by the reporters in this connection.

The reports contain little on the subject of the partial softening of the water in the feed heater. According to Mr. Bals, as a consequence of the considerable velocity of the water in the exhaust steam injector, there is practically no deposit of scale. This is one reason why the performance remains constant and does not fall off after a long period of working. In those types which require pumps, especially surface heaters, a partial softening and de-aeration takes place which may be expected to have a harmful effect on the life of the boiler plates and tubes. Unfortunately, this question of boiler scale in feed heaters has contributed to rendering them unpopular with some managements. Thus the Madrid to Saragossa and Alicante Railways and the North of Spain Railways have discarded surface heaters on principle because of the great troubles resulting from scale. After initial difficulties the Deutsche Reichsbahn modified the form of the heater to meet these conditions, and builds it with straight tubes which can easily be cleaned and provides a reversing cock so that it can be worked alternately with one direction of flow and then the other. No trouble is now experienced with cleaning in a bath of diluted hydrochloric acid. In this connection it may be mentioned that the German Reichsbahn has for the past ten years always fitted a scale separator in conjunction with feed heaters, and these have proved of great value both from the operating and maintenance points of view.

Oil separators are always used with feed heaters which return the condensate to the tender reservoir or which depend upon the mixing of the exhaust steam with the feed water. The method of operating varies in the different types of apparatus; it depends upon change of direction, centrifugal action or filtration with wood charcoal. Generally speaking the seperation of the oil is satisfactory and there is no knowledge of undue contamination of the feed water by oil.

With all feed water heating apparatus there is undoubtedly a danger of freezing if the instructions are not observed when they are out of use. In particularly cold countries it also becomes essential to provide careful insulation and frost-proof casings. But if the instructions are followed the number of cases of damage during an ordinary Winter is small.

On many lines the feed water heater is provided with a special auxiliary live steam valve in order to prevent cold water being fed into the boiler when the

regulator is closed. It is usually operated by the pressure in the valve chest. The Reichsbahn runs some 15 000 feed heaters without a device of this kind and endeavours to educate the locomotive crews to obtain the full advantage of the feed heater while the engine is running under steam. The A. C. F. I. (Société Auxiliaire des Chemins de fer) is now equipping locomotives on which their apparatus is installed, with hot water tanks of from 500 to 1 000 l. (110 to 220 Imp. gallons) capacity. These can be filled when running under steam from the overflow of the injector and deliver a supply to the injector again when the throttle is shut. Eleven engines with this arrangement are already in use on the Alsace-Lorraine Railways and they propose to adopt it on another seventy.

Some estimates of maintenance costs are made by Mr. Parmantier and Mr. Bals; these are reproduced in the hereafter :

1. Exhaust steam injector, Friedmann : 1.50 fr. per 1 000 train km. (2.41 fr. per 100 train-miles);

2. Surface heater, Knorr : 29.15 fr. per 1 000 train km. (46.90 fr. per 1 000 train-miles);

3. Contact heater, ACFI/RM : 21.90 fr. per 1 000 train km. (35.24 fr. per 1 000 train-miles).

It may be safely assumed that the estimate 1) is in gold francs, whereas 2) and 3) are in French francs. By making the appropriate conversion the actual comparison is found to be :

for 2) : 4.8 gold-fr.
for 3) : 3.43 gold-fr.

No further data is available. The reason for this variation in costs of maintenance is evident. It arises from the fact already mentioned, that surface and contact feed heaters are subject to the deposition of scale and must, therefore, frequently undergo a thorough cleaning if their efficiency is to be maintained in service; with injectors on the other hand it is only necessary to change a few nozzles occasionally.

In point of weight also the exhaust steam injector is superior to every other system of feed heating. The complete output weighs 150 to 200 kgr. (330 to 440 lb.), whereas contact and surface heaters weigh 1 000 to 1 200 kgr. (2 200 to 2 640 lb.). In some circumstances the lower weight is a deciding factor, as when existing engines are to be equipped and their weight is already near the permissible limit.

III. — CONCLUSIONS.

The general inference may be drawn that the provision of feed water heaters of one type or another is to be recommended on economic grounds. Mr. Bals and Mr. Gresley desire to see preference given to the exhaust steam injector as the cheaper and simpler in operation and maintenance. Mr. Parmantier is of the opinion that surface feed heaters should be superseded by contact heaters. The report of the Deutsche Reichsbahn shows that they continue to give the preference to surface feed heaters of the Knorr type.

IV. — Air preheating.

A limited amount of experimental work has been done on preheating the air supply to the furnace, but no information is given by the reporters on the success attained. Mr. Lentz expresses the view that air preheating will only make further progress and show considerable economic benefit when new types of boiler construction are introduced.

A step in this direction has been made recently by Mr. Gresley on a high-pressure locomotive for the London & North Eastern Railway. No particulars of the results are as yet available.

V. — Valve gear.

1. *Walschaerts type.*

No innovations of first-class importance have been generally recognised and made use of in this field, comparable with higher steam pressures and increased superheat. Such modifications as have been developed on Walschaerts (Heusinger) gear, which is still the principal type even for new engines, for the purpose of improving the steam economy of piston valve locomotives, continue to be restricted to a comparatively small group of railways. These are increased valve travel and valve motions with limited cut-off.

— Mr. Parmantier refers to experiments on the French Est Railway with valves having larger steam passages to the cylinders, increased lap and in consequence greater travel. This development has arisen from the experience that compound engines with their larger steam passages in the valves run better than engines with simple expansion. On the fifty experimental locomotives put into service, the valve travel was increased from 135 mm. to 273 mm. (5-5/16 to 10-3/4 inches) and the inlet ports from 27 mm. to 50 mm. (1-1/16 to 2 inches). Hence, in the main this is a question of reduced throttling losses. An advantage in the case of engines working on light duties undoubtedly lies in the fact that this reduced inlet throttling enables them to be driven with very early cut-offs. Special comparative tests in service showed a fuel economy of more than 4 % in favour of the engine with the gear let well out.

— Mr. Gresley also draws attention to the fact that it is worth while endeavouring to use increased lap and valve travel with piston valves.

There has been a marked tendency in recent years to go over to larger valve travels on new engines in the United States. This is not given special prominence in Mr. Lentz's report as it is not a question of a fundamental alteration of type.

— So far the principle of the limited cut-off is restricted solely to America, and it is described in detail by Mr. Lentz. Formerly the practice there, as in most other countries, was to design the cylinders of freight and shunting locomotives for a maximum cut-off of 85 to 90 %. Compared to the tractive power of the engine the cylinders were small, and low efficiency resulted owing to incomplete expansion, since it was always necessary to work with a late cut-off. It was often impossible to increase the cylinders within the prescribed gauge, and, further, it was desired to avoid large cylinder weights and heavy reciprocating masses. A way out of the difficulty was sought in the use of the following new ideas : increase of steam pressure; introduction of limited cut-off and of valve gear with increased valve travel. The limitation of cut-off so as to permit a maximum admission of 55 to 65 % only guarantees that full use is always made of the expansion of the steam and consequently a good cylinder efficiency is attained. A special port in the cylinder allows greater admission (about 85 %) to be used at starting. The valve travel was increased to about 225 mm. (9 inches) and the port lap widened correspondingly.

More than 1 000 locomotives have already been arranged on these lines in America and Canada. Mr. Lentz reports that good experience has resulted from these engines, especially in the case of slow-running units; fast engines are in any case run with earlier cut-offs, and, therefore, use the steam to better advantage.

In connection with the adoption of limited cut-off an indicating device has been fitted in isolated cases for the purpose of showing the driver whether the position of his gear is giving the best

utilisation of steam at the particular speed. A speed indicator is fitted with a second pointer, which is connected by link work to the valve control gear in such a way that the two pointers are exactly in line with one another when the cut-off point is correct. Tests demonstrated that a fuel saving of 15 % could be effected by using this device.

The remaining reporters state that the necessity of introducing the limited admission principle has not been discussed.

2. *Special designs of valve gear.*

The demand for improvement in the existing types of valve gear has given rise to special designs having the following objects in view :

1. Quicker uncovering of larger steam paths at admission and exhaust and consequent reduction of the losses due to throttling.

2. Obviating the interdependence between admission and exhaust and thereby obtaining greater compression at early cut-offs.

3. Reduction of the reciprocating masses.

4. A real simplification in service and in maintenance.

The solution of these requirements has been sought partly in the sphere of slide valve gear and partly in the adoption of valves of the poppet type.

a) *Improved slide valve gear.* — Gears under this heading which are used in America are those of Baker and Young and the Southern gear. Mr. Lentz includes in his report detailed descriptions with particulars of the advantages of each design. The following are brief extracts :

— *Baker valve gear.* — The motion is transmitted as in the Walschaerts gear from the cross head and a return crank. The links and link blocks are replaced by a guide, the parts of which are assembled with bolts and bushes. The motion of the valve is of such a kind that it has a maximum velocity at the dead centre position of the piston and, therefore, uncovers the ports as quickly as possible. Replacement of any parts that may become worn can be effected very expeditiously, as it is only necessary to change bolts and bushes. More than 12 000 locomotives have already been equipped with this gear in America.

— *Young valve gear.* — The principle of this is the same as that of the Walschaerts gear, but the valve motion is effected from the cross-heads only. As the cross-heads in the two-cylinder locomotive are displaced by 90° relative to one another, it is possible to give motion to each link from both crossheads in exactly the same way as from a link and a return crank.

The advantage of this arrangement, according to Mr. Lentz, is that it confers freedom from the error which is introduced into the valve motion owing to the wheels and the movement of the sprung parts of the engine. Also the Young gear has been developed for large valve travels, the advantages of which have already been fully explained. 513 engines with this gear are now operating in America.

— *Southern valve gear.* — Just as in the Young gear, the valve motion is derived from the movement of both crossheads; the Southern gear uses the two crank pins, which are also 90° apart, for driving the links. This allows the lap and the lead to be altered by raising or lowering the eccentric rods and the length of the valve travel to be modified by a horizontal movement. The main advantages put forward are a very uniform steam distribution at any cut-off, full port openings with the shortest stroke and small amount of wear. This gear is in use on 2 155 engines.

b) *Poppet type valve gear.* — Valve gear of this type has been fitted by various railways, although mostly for experimental purposes only. It is assumed that the constructional details of this type of gear are already known to readers. The reports refer to the following types as being in operation :

— *Lentz and Paxman types* with oscillating rods having lifting curves and vertical valves : 11 engines on the Madrid-Saragossa-Alicante Railways, 5 compound locomotives on the Paris-Lyons-Mediterranean Lines and 1 compound locomotive on the Polish State Railways.

— *Lentz type* with horizontal revolving camshaft and valves : 2 locomotives in Poland, 2 on the Netherlands Railways, and 3 three-cylinder engines on the London & North Eastern Railway.

— In addition, 1 *Jendrusik* type and some engines with the Meyer-Mattern valve gear on the Netherlands Railways.

Whilst the poppet-type gears so far mentioned only have the advantage of uncovering a larger steam passage in a shorter time than the usual Walschaerts valve gear, with the Caprotti and Dabeg types (with revolving camshafts) the compression is independent of the steam opening and can be adjusted to give the most favorable conditions. By this means it is possible to obtain a sufficiently perfect indicator diagram, even with early cut-offs; on the other hand, the constant compression renders it more difficult to obtain correct buffering of the reciprocating masses at different speeds.

The Dabeg gear has only been installed experimentally on the Madrid-Saragossa-Alicante and the Paris-Lyons-Mediterranean Lines.

Caprotti gear, however, has already been introduced to a considerable extent on the Italian State Railways. At the moment 270 engines of the most varied types are equipped with it. Although there is an absence at present of detailed information concerning its behaviour in service, its maintenance and any fuel economy, it may be inferred from the headway it is making that it is giving satisfactory results. It is desirable, however, that still more information should be given, especially as to whether any saving of fuel can be credited to it for new engines in addition to the reduction of maintenance charges.

3. *Combined valve gear.*

The reporters give some examples of the valve arrangement on multi-cylinder engines. Mr. Bals, Mr. Lentz and Mr. Parmantier deal with three- and four-cylinder locomotives with simple expansion, in which the motion of the inner valve is derived from that of the outer ones by link work. As an example of independent valve motions for simple expansion, Mr. Bals mentions the Danish three-cylinder engines in which the motion of the middle valve is obtained from an eccentric on the left-hand side of the engine by means of link work. The Rumanian Railways have four-cylinder simple expansion locomotives with only one valve for the pair of cylinders on each side.

According to Mr. Bals, the four-cylinder engines with two-stage expansion in Norway, Sweden and Rumania have a high-pressure and a low-pressure cylinder on each side and these have a common valve on the Vauclain principle. The Reichsbahn also has engines of this type. Mr. Parmantier gives as other examples of compound valve gear, those on the Paris-Lyons-Mediterranean Lines, in which the inside lap-and-lead lever is retained, and engines on the Italian State Railways with no inner lap-and-lead lever.

No additional details with regard to tests or experience obtained have been given by the reporters. Moreover, the views as to the relative advantages of

combined or independent valve motions are conflicting. Mr. Bals is of the opinion that in spite of their high initial cost and maintenance charges, independent valve motions are preferable, but he does not explain whether this holds good to the same extent in the case of simple expansion and compound engines. Mr. Parmantier, on the other hand, sees an advantage in combined motions, so far as compound engines are concerned, because they render it possible to obtain good steam utilisation, independent of the driver. The Reichsbahn, although they are no longer bulding compound engines for normal pressures, now prefer the independent valve motion on the centre cylinder of three-cylinder locomotives for the reason that faulty steam distribution results from transmitting the motion by levers from the outside gear.

VI. — Draught and steam exhaust.

Generally speaking, railways have adhered to the forms of blast pipe design which they have hitherto employed. It is an interesting fact that while the railways in the countries represented by Mr. Parmantier firmly believe in the necessity for a variable blast pipe opening, the lines in the countries reported on by Mr. Bals and Mr. Gresley, and the Deutsche Reichsbahn, are satisfied with the fixed blast pipe.

A new departure of some significance referred to in the reports is the introduction in some cases of Kylala blast pipes and other designs based on that one.

Kylala pipes have been tried by various lines, e. g. a number of French railways, the North of Spain Railway and Finland. There are divided opinions as to its advantages. It has been discarded by the French lines because it has not a variable discharge orifice; it has only been retained on the North of Spain Railways.

The Paris-Orleans and the London & North Eastern Railway have tried designs of blast pipe evolved from the Kylala and have had good results. Mr. Parmantier's report gives a curve showing the blast pipe pressure obtained; 100 engines on the Paris-Orleans Lines have already been equipped. The London & North-Eastern Railway, while satisfied with the draught obtained, has not yet been able to confirm any appreciable saving in fuel.

Belgium has adopted a double (two concentric pipes) discharge on locomotives of large sizes, and the Bergslagen Railway is using a triple discharge on high speed engines. Recently Belgium has fitted a double discharge to all engines having a grate area of more than 4.2 m² (45.2 sq. feet).

The reports do not, however, yield any indication of consistent practice, and it can only be said that tradition in each country plays an important part in the choice of blast pipe design.

The turbo-blower driven by a Rateau exhaust steam turbine has been tried only by the Paris-Lyons-Mediterranean. No final opinion has been given, but it is believed that very rapid wear of the blower wheel has to be faced.

According to the reports, the provision of wind screens has proved to be the most effective means of preventing the beating down of smoke and steam in normal running as was recognised by the Deutsche Reichsbahn six years ago. The French Est Railway has obtained satisfactory results by shaping the parts which project over the smoke box and cylinders.

VII. — Miscellaneous questions.

1. *Compounding.*

In recent times some railways have entirely given up compound working, cases in point being Rumania, Sweden, Czecho-Slovakia and the Deutsche Reichsbahn.

Only the last-named has undertaken special comparative tests on a broad experimental basis between engines with simple and compound expansion respectively; for this purpose they built ten express train locomotives of their standardised series 4-6-2 (Pacific) as two-cylinder simple and ten as compound. The cylinder ratio chosen was 1 : 2.45. The results showed that only at loads exceeding 750 H . P. was there a gain of up to 6 % in the maximum output, but at the lower duties more usually required the compound engines were inferior. In view of the increased capital cost and maintenance charges, the small fuel economy obtained gave no encouragement for building further engines of this type.

Mr. Gresley also believes that the gain conferred by compounding at normal pressures is too small, and that from an economic point of view it can only come into use again when boiler pressures are considerably increased.

In recent reconstructions of engines to work with superheated instead of saturated steam, compound working has for the most part been discarded in favour of simple expansion. This has been the case on the Czecho-Slovakian State Railways, the Alsace-Lorraine Railways, and in Sweden.

Other railways on the contrary, such as the Belgian National Lines, continue to build compounds. It is clear, therefore, opinion is still divided as to the extent to which the overall economy is affected by maintenance charges.

2) *Other improvements.*

A large number of modifications and improvements are referred to by the reporters, which cannot be discussed in detail within the limits of this summary, especially as the majority are experimental designs. Reference should be made to the original reports for details.

a) *Improved combustion devices.* — According to Mr. Parmantier's report combustion chambers have been tried by five railway managements.

Various new designs of grates, such as rocking grates or corrugated fire bars, have been incorporated for experimental purposes on some lines. The drop grate continues to find increasing favour.

The « Langer » smoke-consuming device which operates by injecting steam is being tried on the Austrian lines, the Swiss Federal Railways and the Polish State Lines. It is said to require for its proper working a « draught corrector » — a diverting device in the smoke box. As a saving of 10 to 12 % in fuel is said to be effected by its use on passenger and express train engines, it is to be tried also by the Rumanian State Railways.

b) *Improvements in water circulation.* — Thermic syphons and water tubes in the fire box are being incorporated experimentally by several railways. In some cases the method of fitting these is being used in connection with the supporting of the baffle. Although there has not been sufficient time for conclusive results to be given, Mr. Gresley and Mr. Parmantier are in agreement that these devices only introduce difficulties in construction, operation and upkeep with scarcely any compensating advantage. It is certainly a fact that from time to time maintenance troubles have been experienced in the U. S. A. and on the Deutsche Reichsbahn, although it is undeniable that they tend to minimise the formation of scale owing to the improved water circulation, and what is of the greatest importance, the boiler evaporation is appreciably increased. For these reasons the syphon has found extended use in America; in Germany it is used to increase the output of the boiler on locomotives of old types.

c) *Regulators.* — Of the various new types of regulator the multiple throttle of

American origin deserves mention. Mr. Lentz has given a full report on this in Section II. Mr. Gresley includes a drawing showing the form in which it is employed on the London & North Eastern Railway. The regulator is located on the superheater side, in the superheater header and permits very gradual opening of the individual steam valves. Compared with the usual type of regulator located in the dome, this design has the advantage that both the regulator and the regulator rod are easily accessible. The Swedish State Railways, the Bergslagen Railway and others have experimentally adopted the arrangement of fitting the regulator behind the superheater. No information is given concerning the effect upon the superheater elements.

d) *Soot blowers.* — Soot blowers for cleaning the tubes whilst running have been tried in a number of cases. Their success is doubtful and no final opinion is available. In any case, these devices have not been adopted widely.

e) *Booster.* — It is well known that while the « booster » is found extensively in America, its use is practically confined to that continent. According to Mr. Gresley's report, the Canadian National Railways have in operation 61 engines with the booster fitted on the locomotive bogie and 6 with it mounted on the tender bogie. In Europe, the London & North Eastern Railway alone has equipments of this kind fitted on 3 locomotives. Mr. Gresley gives a diagram of the booster arrangement. No further information is given concerning the results obtained over and above the increased tractive effort.

f) *Special light alloys.* — Special alloys of light weight have been made use of only in one case cited by Mr. Bals, which relates to an attempt on the part of the Czecho-Slovakian Railways to manufacture pistons and valves in aluminium. The result was not encouraging.

Special steels of the most varied compositions are used by many undertakings for the highly stressed parts of locomotives. Further information on this point is given by all the reporters.

g) *Lighting.* — Steam locomotives are still illuminated mainly by lamps burning petroleum and other oils. It is gathered from the reports, however, that there is a general movement towards modernising this detail of the equipment. Most railways have introduced gas or electric lighting to a greater or less extent as an experiment, and some have already changed over entirely to these methods of illumination. The system which appears to have the best prospect of being widely adopted, in spite of its high cost, is certainly electric lighting from a steam turbo-generator. The equipments generally used are of 350 to 500-watt output at 24 to 35 volts. The steam consumption is given by Mr. Bals as 36 to 52 kgr. (79.4 to 114 lb.) per hour, which coincides with the experience of the Reichsbahn. The use of acetylene from cylinders has also many adherents by reason of its lower cost.

h) *Lubrication of wheel flanges.* — Information on this subject is given only by Mr. Bals and Mr. Parmantier. Some railways have in operation apparatus which either deliver a constant flow of oil or else vary the quantity according to the speed (Buclon system). It is stated that the effect on the wear of the tyres is considerable. The French Midi Railway reports that their life is doubled; consequently all engines which have to run over curves of 300 m. (15 chains) or less are being equipped. The Paris-Lyons-Mediterranean Railway has fitted the Buclon apparatus to 250 locomotives and has proved that under operating conditions the wear of the wheel flanges has diminished from 30 mm. per 100 000 locomotive-kilometres to 10 mm.

One railway (the Paris-Orleans) is also trying out apparatus which lubricates the inner side of the rails. No results of the tests are yet available.

i) *Balancing.* — Opinions as to the extent to which balancing is necessary are varied. The following table discloses the statements made in the reports.

RAILWAY.	Extent to which the reciprocating masses are balanced.
French Nord for 4-cylinder locomotives & Paris-Lyons-Mediterranean.	0 %.
French State	Alternately, so that the maximum additional load for each wheel amounts to 1 500 kg. (3 307 lb.).
Paris-Orleans	Alternately, so that the maximum additional load for each wheel amounts to 1 200 kg. (2 645 lb.)
French Nord for 2-cylinder engines.	30 %.
Madrid-Saragossa	33 %.
French Est	As fully as possible; the limit is an additional wheel loading by the balance weight of 80 % of the unsprung weight of the coupled axles.
Those covered by Mr. Bals' report.	15 to 60 %. The limit is, in general, an additional wheel loading by the balance weight at the maximum speed of 15 % of the wheel weight.

Information is lacking as to whether the balancing of the coupled axles is practicable.

Conclusions.

The improvements which have been introduced into reciprocating locomotives during the short period 1922-1928, and which have resulted in appreciably raising the effectiveness and economy of our normal steam locomotives, lead us to anticipate that further development will continue for some time and that considerable progress may be expected.

[621 .335]

QUESTION VII.

(ELECTRIC LOCOMOTIVES FOR MAIN LINE TRACTION) (1),

by G. BIANCHI,

Special Reporter.

The object of the present report is to summarise the reports presented on the question of *Electric locomotives for main line traction : a)* Passenger; *b)* Goods; *c)* Mountain lines, and Multiple unit working, by Messrs.:

J. V. B. DUER, for America (2);

K. ASAKURA and H. IMAIDZUMI, for the British Empire, China and Japan (3);

DE BOYSSON and LEBOUCHER, for France and colonies (4);

BIANCHI, for all other countries excluding Germany (5).

As the different reports have many observations and ideas in common, in order to avoid much repetition it has been thought better not to summarise each separately, and consequently the facts and conclusions have been grouped under the most important points covered.

I. — Classification of electric locomotives.

The classification of electric locomotives into three groups : passenger, freight, mountain, proposed in question VII has not been considered by the different reporters as being the best; they have generally adopted a classification according to the transmission between the motors and the wheels combined with arrangement of the carrying and driving wheels.

II. — Types of transmission from the motor to the wheels.

A. — Armatures keyed on to the axles (gearless locomotives).

The locomotives of this design have remained few in number and it appears that the gearless type will not be used again in new construction;

B. — Motors suspended by the nose.

All the reports mention a number of continuous current locomotives with this type of drive.

The conclusions agree on the following points :

1. The drive by two symmetrical trains of gears is often preferred in order to eliminate torsion effects and to get a symmetrical effort on the driving axles.

It is observed however that the unilateral drive is also frequently used owing to the need for giving the motor the maximum width possible and making it easy to inspect the commutator and facilitating fitting up the brake gear, etc. In this case it is necessary to make the gears and bearings wide enough to stand the unsymmetrical stresses to which they are subjected.

2. As regards the gears it has been found that toothed wheels having renewable rims in two pieces of forged steel

(1) Translated from the French.

(2) See *Bulletin of the Railway Congress*, July 1929 number, p. 887.

(3) See *Bulletin of the Railway Congress*, September 1929 number, p. 1681.

(4) See *Bulletin of the Railway Congress*, September 1929 number, p. 1733.

(5) See *Bulletin of the Railway Congress*, December 1929 number, p. 2997.

fastened to the wheel centre itself are better liked than either single piece forged steel wheels or cast steel wheels in two pieces.

The use of elastic gearing does not appear essential if the power and weight per axle is not very high.

3. The low position of the motors and the considerable proportion of unsprung weight have not prevented locomotives having the motor suspended by the nose, even when not provided with guiding wheels, from reaching and exceding speeds of 90 km. (56 miles) per hour; the behaviour on the line appears above all to depend upon the method of coupling between the bogies and upon the springing of the body.

The report of Messrs. de Boysson and Leboucher gives particulars of the arrangements used for this purpose.

4. It has however been observed that some locomotives having the motor supported by the nose, when not fitted with guiding wheels, have given, as regards the stresses set up in the rails and the wear of flanges, less satisfactory results than locomotives of the same type fitted with guiding wheels. Very interesting observations on this subject are given in the report of Messrs. Asakura and Imaidzumi.

5. A new layout for nose suspended motors adopted on the Detroit-Toledo-Ironton Railroad is mentioned in Mr. Duer's report. The weight of the locomotive is carried by the frame of the motor, which is carried on the axles by axle-boxes forming part of the motor itself. The drive is by a double elastic gear.

C. — Individual gear drive of the axles with the motors rigidly mounted on the truck.

The individual axle drive with motors rigidly fastened to the frame has given rise to many systems :

a) Quill drive systems differing in the method by which the hollow shaft is connected to the wheels, such as by springs, short rods, or a combination of both.

New arrangements using springs are mentioned in the report by Mr. Bianchi, and new designs of springs with rods in the reports of Mr. Duer and of Messrs. de Boysson and Leboucher.

b) With gears carried on a shaft projecting from the frames and outside the outside face of the driving wheels. These gears are connected to the wheels by rods (see reports by Messrs. de Boysson and Leboucher and by Mr. Bianchi).

c) With vertical motors and conical pinions driving a double toothed wheel fastened to a hollow shaft (see report by Messrs. de Boysson and Leboucher).

Usually the power transmitted to each driving axle is great, the resulting centre of gravity as a result is very high, and the vehicle rides very well. In consequence of this, these systems are used especially in the case of single-phase and continuous current locomotives intended to run at high speeds.

A criticism made however is that, on locomotives having the motors carried above the frame, there is difficulty in arranging the control gear inside the cabs in such a way that it can be readily inspected.

D. — Gear and rod drive. — This drive is used when there are one or two traction motors and several driving axles. In the case of two motors being used the drive from the gear wheel shafts to the driving axles is usually by means of triangular rods if the plane of the gear wheel shafts is different from that of the wheels, or by straight rods if the planes are the same or closely so vertically. These systems are mentioned in Mr. Bianchi's report as being prefered for single-phase and three-phase 45-period frequency locomotives.

E. — Systems using rods. — Rods are used on most three-phase locomotives of 16.7 periods, on several single-phase

locomotives and on a small number of continuous current locomotives.

In the reports by Messrs. de Boysson and Leboucher and that by Mr. Bianchi the recently introduced systems using articulated rods are mentioned; these rods, unlike the rigid triangular rods, make it possible to obtain a greater distance between the motors and the wheels without the weight of the driving mechanism as a whole becoming excessive.

These types of rods can be calculated statically which makes it possible to use higher values for the unit stresses.

III. — Arrangement of the bogies and bodies.

From this point of view the electric locomotives can be classified as follows :

a) Locomotives the total weight of which is adhesive, with rigid frame;

b) Locomotives the total weight of which is adhesive, but with two or more articulated trucks or two or more bogies with driving axles;

c) Locomotives with driving and carrying wheels with a single main frame;

d) Locomotives with driving wheels, carrying wheels, and articulated trucks.

Included among the *rigid framed locomotives the total weight of which is adhesive* are several single-phase locomotives and most of the three-phase locomotives used for goods services and in mountain country. The weight per axle and the maximum speed of this type of locomotive are generally limited to rather low figures.

Total adhesion locomotives with articulated trucks, with rod, or rod and gear drive, are few in number, whereas those having two or several bogies, either four or six wheeled with the motors suspended by the nose, form the majority of the continuous current locomotives for speeds not exceeding 90 km. (56 miles) per hour.

The different layouts adopted by the locomotives with two or more bogies are the following :

a) Bogies coupled together by means of a coupling with springs damping the oscillations due to nosing or by means of a rigid spherical coupling allowing rotary movements of the bogies relatively to each other.

The buffing and draw gear are secured to the bogies.

The body in the case of $B_0 + B_0$ locomotives is carried on pivots, one on each bogie, one of the pivots being so arranged that it can move longitudinally; or alternatively the body rests on two spherical convex pivots one on each bogie on which it can rock sideways a few degrees, balancing springs being provided so as to return it to its vertical position. Interesting remarks on this point are contained in the report by Messrs. de Boysson and Leboucher.

b) Bogies not coupled together. The body carries the buffing and draw gear. The spring gear is single with equalising levers, or double with bolsters as in the case of carriages.

With the exception of the locomotives with two or more bogies and motors suspended by the nose, which, as has already been said, can run at speeds up to 90 km. (56 miles) per hour, even when not fitted with guiding wheels, it is considered essential in the case of all other types of locomotives when the required speed exceeds 60 km. (37 miles) per hour, to use guiding (leading, carrying) axles to facilitate taking curves and to get steady running.

Many continuous, single-phase, and three-phase current locomotives with three or four driving axles for passenger and goods services belong to this type. In order to facilitate taking curves some of the driving axles are arranged so that they can move laterally.

The locomotives with driving and carrying axles and articulated trucks are intended to work heavy trains for

which a great adhesive weight is needed. All types of transmission are used.

As regards the coupling between the trucks, experience has confirmed the necessity of reducing the vertical and longitudinal play as much as possible. The bodies are often divided into two or three articulated parts.

As this layout makes it more difficult to fit in the electric equipment, a single body carried on the trucks is often used.

The layout of body generally considered best consists of two driver's cabs at the ends, a central compartment in which the electric equipment is fitted, and one or two corridors; occasionally there are also two bonnets at the ends.

Great importance is given to the arrangement of the equipment so as to make it as accessible as possible for inspection and maintenance.

Information on this point is given in the reports by Messrs. Duer and Bianchi.

IV. — Wheel arrangements.

The most frequent wheel arrangements are the following :

Single-phase locomotives :

${}_0D_0$, D + D, 1C1; 1C2, $1C_02$, $1D_02$, 1E1, 2B2, B + B, $B_0 + B_0$, 1B + B1, 2B + B2, 1C + C1, $1C_0 + C_01$, 1C1 + 1C1, 1D1 + 1D1.

Continuous current locomotives :

$B_0 — B_0$, $B_0 + B_0$, $B_0 + B_0 + B_0$, $C_0 — C_0$, $C_0 + C_0$, 2D2, $1C_0 + C_01$, $2B_0 + B_02$, $2C_0 + C_02$, $1A_0 + B_0 + B_0 + A_01$.

Three-phase locomotives :

oEo, 1C1, 2C2, 1D1.

The lateral displacements of the guiding bogie pivots do not exceed 150 mm. (6 inches); that of the carrying wheels 100 mm. (4 inches); that of the driving wheels 25 mm. (1 inch).

Several administrations have pointed out the advisability of reducing to a minimum, on locomotives having a single frame, the number of driving axles given lateral movement.

V. — **The weight per axle** of European electric locomotives does not exceed 21 tons; that of American locomotives reaches 36 tons. The weight per metre over buffers varies between 5 and 7.3 tons for European locomotives and reaches 13 tons on American ones.

VI. — **The coefficients of adhesion** relative to continuous working at the maximum hourly rating are about the same for the different types of locomotive. The maximum values reported are respectively 1: 4.6 for the hourly rating, and 1: 5.1 for continuous rating.

For the maximum effort of several types of locomotive, values are obtained which often exceed the practical adhesive limit commonly taken as being 1: 3.

VII. — Lubrication.

In all types of electric locomotives it is noticeable that the lubrication systems although not showing any real originality are more carefully worked out both as regards certainty of working and as regards economy of oil consumption than those at present fitted on steam locomotives.

Electrical part.

VIII. — Current collecting devices.

The current is collected from the overhead line by means of pantographs for the locomotives of the different systems, except in the case of certain three-phase locomotives on which there is a double collection by trolley and for locomotives with the third rail. Two systems are followed for operating the pantograph:

a) the pantograph is raised by the action of compressed air on the piston of a cylinder which puts in tension the springs giving pressure on the contact line. The pantograph is lowered by

gravity by letting the air out of the cylinders.

b) the pantographs are raised by means of springs always in tension which give the pressure on the line and are folded down by the action of compressed air which counteracts the action of the said springs.

The first system requires the conductor to raise the pantographs by hand, either directly or by an auxiliary pump when the pressure of the air in the auxiliary reservoir falls below the minimum value required for lifting.

With the other system, raising and lowering the pantograph is quicker. Some companies consider that as a result of the lock needed to guarantee the lowered position, this system is less certain as regards the safety of the staff.

The pressure of the rubbing strip on the contact line is 3.5 to 4.2 kgr. (7.7 to 9.2 lb.) for the 15 000-volt single-phase locomotives, 6 to 7 kgr. (13.2 to 15.4 lb.) for each-phase of the 3 700-volt three-phase locomotives and from 7 to 12 kgr. (15.4 to 26.4 lb.) for the continuous current 1 500 and 3 000-volt locomotives.

It is estimated that this pressure for a given power of the locomotive is almost in proportion to the intensity of the current collected by the different systems of traction.

IX. — Lightning arresters.

On the single-phase and three-phase locomotives the present tendency is not to provide any fitting for protection against excess voltages. For the continuous current locomotives, on the other hand, it appears to be essential to provide protection against such excess tension.

In their report, Messrs. Asakura and Imaidzumi have made a number of observations on the subject of the abnormal over-voltages noted when the current is cut off suddenly. These over-voltages last a very short time and, although the consequences as regards the insulation of the machines may not be fully known, they are often the apparent cause of arcing.

In the different reports are mentioned the apparatus most frequently used on continuous current locomotives to protect the equipment against over-voltage effects : electrolytic lightning arresters; lightning arresters with condensers and resistances combined; lightning arresters of the born type and with coil. The above mentioned devices, however, do not appear to be really efficacious against over-voltage effects.

X. — Circuit breakers.

The breakers in the traction circuit of electric locomotives can be separated into two categories :

1. Breakers which are closed when the locomotive is started and which open automatically by relays when the current becomes excessive or when the voltage exceeds a given minimum or maximum value.

2. Breakers which close or break the traction current by the direct action of the driver. On certain locomotives the two functions 1 and 2 are fulfilled by the same breaker. As regards breakers of group 1, they can again be subdivided into two classes :

a) Apparatus which break the circuit when an abnormal intensity, of no matter what value, occurs in one of the high tension circuits of the locomotive. The break is made quite independently of the action of the circuit breakers in the substations or of the feeder lines.

Amongst this class are the breakers on alternating current locomotives, the operation of which is solely decided by the action of overload relays or relays set for a maximum voltage and the quick or extra-quick break relays of the continuous current locomotives which.

operate independently of the other breakers of class 2.

b) Breakers which in the case of a violent short circuit only open after the nearest contact line section breakers have opened, a special device preventing the working of the no voltage and maximum current relays until after the said section breakers have come out. These devices are fitted on single-phase locomotives.

On continuous current locomotives in place of breakers coming into class *a*), in some instances, the same circuit breakers by which the driver opens the traction circuit are used. These breakers only open when the intensity of the short circuit has been reduced to the normal value, or even below it by the action of an overload relay which before the breakers come out put into the circuit starting resistances.

In the reports of Messrs. de Boysson and Leboucher and of Messrs. Asakura and Imaidzumi breakers of class *a*) (*i. e.* of the extra-rapid type) on high tension continuous current locomotives are preferred to those of class *b*) and the need for inserting suitable resistances, before cutting off the current, is considered.

As regards circuit breakers of type 1 or type 2 for alternating current locomotives the following conclusions are made:

Oil breakers having some danger of explosion in the event of opening under short circuit, several companies have been led to adopt similar arrangements to that mentioned under *b*) or to consider the use of air breakers which are a more certain protection against explosion.

As regards the use of shock resistances and explosion chambers for alternating current breakers, opinions are divided.

XI. — Equipment.

In single-phase locomotives the speed is controlled by electropneumatic or electromagnetic contactors or by mobile contacts on a cylinder or in line, operated by an electric or electromagnetic servomotor. The opinions on this point are again divided.

On continuous current locomotives electropneumatic, camshaft or electromagnetic control is used.

The electropneumatic control with or without the use of the camshaft control for certain apparatus such as motor combiners or reversing gear, etc. is preferred.

In three-phase locomotives, the equipment consists of cylindrical combinators intended to connect up different numbers of poles of the motors and which work without current and without voltage and of a main starting rheostat of the soda-water type which is shunted across the windings of the rotors.

XII. — Transformers.

In single- and three-phase locomotives at 45 periods, oil transformers are almost entirely used.

The maximum temperature allowed in the windings never exceeds 100° C. (212° F.) and that of the oil 90° C. (192° F.).

The oil is cooled by circulating it outside or by circulating air inside the casing of the transformers.

XIII. — Traction motors.

On continuous current locomotives working on 1 500 to 3 000 volts and for speeds up to 90 km. (56 miles) per hour the type of traction motor with spring suspended nose with four poles and commutation poles is the most used.

For locomotives for higler speeds single or double motors (twin motors) rigidly fastened to the locomotive frame are the most used.

For single-phase locomotives, the present tendency is to raise the number of

revolutions, increase the number of poles and suppress the resistances between the windings and the segments of the commutators. The motors are generally fastened rigidly to the trucks so as to be able to use the gear and rod drive or the individual gear drive.

The three-phase 16.7-period locomotives are fed at line voltage. In order to reduce the coupling in cascade, recently motors have been used which can have three numbers of poles, *i. e.* three speeds. The motors are rigidly fastened to the truck and the rod drive is the only one used.

The motors of the 45-period three-phase locomotives are fed at reduced voltage and are rigidly fastened to the trucks. The drive is by gears and rods.

The following statements apply to all types of motors :

Forced ventilation is always used. The ratio of the one hour to the continuous rating is between 1.2 and 1.1. The different administrations agree that the limits of temperature generally adopted up to date for determinig the conventional power are too high for traffic working and result in a too short life of the insulation.

Several administrations report many drawbacks due to this cause.

A very interesting statistical table of the defects of continuous current motors is given in the report by Messrs. Asakura and Imaidzumi.

XIV. — Safety of the staff.

In order to prevent the staff from coming into contact with conductors under tension, regulations have been issued and automatic devices fitted with the object of preventing access to parts under tension until the current has been cut off.

As regards protection against explosion or fire of apparatus containing oil (oil circuit breakers and transformers) devices are used whereby accumulation of gas from the oil is prevented and in addition such apparatus is carried in a part of the locomotive as far away from the staff as possible.

XV. — Matters relating especially to high speed locomotives.

The different reporters find that for goods and passenger locomotives for speeds of up to 90 km. (56 miles) per hour no common tendencies among the different types are observable.

For locomotives intended to run for some time at very high speeds, *i. e.* above 100 km. (62 miles) per hour, the tendency is observable, on the contrary, on the different types of locomotive, to use the individual axle drive through gearing with motors carried high up and rigidly fastened to the frames, and to fit guiding bogies.

XVI. — Matters relating especially to locomotives for use in mountainous country.

A question peculiar to these locomotives is electric braking or regeneration when descending gradients.

The different reports agree upon the following points :

a) Electric braking with or without regeneration greatly increases the safety of working on mountain lines from the brake point of view, as it is possible to feed the brake pipe continuously and to maintain the maximum pressure in the auxiliary reservoirs of the vehicles.

b) On certain mountain systems, the energy regenerated by descending trains can be an appreciable fraction of the power taken by the ascending trains.

c) Regeneration is usually fitted in three-phase locomotives and on the greatest number of continuous current locomotives. On certain continuous current locomotives electric brakes with resistances are fitted.

On single-phase locomotives regeneration or electric braking is hardly ever used.

XVII. — Multiple-unit rail motors.

In the report by Mr. Duer information is given on the American rail motor coaches.

The types of vehicles of the different railways have almost the same main features.

a) Body carried on four-wheeled bogies.

b) Seats on both sides of a central gangway between two end vestibules. Total number of seats 70 to 80.

c) Motors of the nose-suspended type of a power of 120 to 180 kw. at the hourly rating, self ventilated for continuous current and forced ventilation for single-phase.

d) Electropneumatic contactor or cam type control. Automatic acceleration used, obtained by a current limiting relay.

e) The equipment on nearly all multiple-unit rail motor vehicles includes the « dead man's handle » which cuts off the current and applies the brakes if the driving handle is let go whilst running.

f) The highest speed in service of multiple-unit trains is about 100 km. (62 miles) per hour. The acceleration reaches in some cases 0.65 m. (2.13 feet) per second per second and the braking in metropolitan working 1.10 m. (3.6 feet) per second per second.

g) The use of light alloys has made it possible to reduce the weight of the bodies considerably.

SUMMARY.

1. Although the introduction of electric locomotives already dates back some tens of years, electric locomotives still do not show, not even in their general design, the uniformity of design that steam locomotives presented within a few years of their first invention.

This being so, it appears necessary to form conclusions of a general character and to limit the final observations and the discussion to arguments which can be considered as common to the different systems.

2. As regards the *most used types of drive,* the following remarks can be made :

A. — As regards *the system with motors having the nose spring supported,* the most usual with continuous current, if the speed is not to exceed about 90 km. (56 miles) per hour, a discussion on the following points would appear to be useful :

a) What are the maximum limits of power, weight of motor, and speed, with this system, which can be used in practice ?

b) What are the limits of power and axle weight for which gears with spring drive are considered preferable?

c) What has been the experience of the different administrations as to the action on the rails and the wear of wheel flanges of locomotives with the motors, the nose of which is spring supported, and fitted or not fitted with leading axles or bogies?

B. — *The individual drive of the axles* by gearing and motors rigidly fastened to the main frames has resulted in quill drives or drives by gears projecting beyond the outside face of the driving wheels or in vertical motors driving through conical wheels and hollow shafts.

As regards quill drives, which are the most used, a discussion on the results given by the different types of springs or rods used to couple the hollow shaft to the wheels would be of value.

It would also be of interest to learn what is thought of the results obtained with the two other systems.

C. — On locomotives with low speed motors, articulated rod types of drive have recently been introduced and these theoretically have advantages over the older rigid triangular rods. It may be asked if these advantages are confirmed in practice.

3. There is still no standard arrangement of *trucks and bodies* except for the types formed of several bogies all the axles of which are driven with motors of the spring supported nose type which types are very usual among continuous current locomotives for passenger and goods working at speeds not exceeding 90 km. (56 miles) per hour.

On this subject a discussion on the following points would be interesting :

a) Should the bogies be coupled directly together, the draw and buffing gear be fastened to the bogies themselves, or should the bogies not be coupled and the draw and buffing gear be attached to the body?

It would also be useful if the different types of springing used for the bodies were discussed :

a) Locomotives with driving and carrying axles with a single main frame often have driving axles which can move laterally up to as much as 25 mm. (1 inch).

On some locomotives all driving axles can move laterally whilst on others only one or two axles can move in this way and to the minimum permissible extent. It would be interesting to know which system gives the best results.

4. Generally speaking the *axle load* allowed for electric locomotives is higher than that allowed on the same railway for steam locomotives. It is also known that certains types of electric locomotive, in particular those with individual gear drive and with the motors on the frames, although the weight per axle is higher than on other types, have shown that they do very little harm to the track and run very steadily at even the highest speeds.

It would be interesting to hear a review of the observations made on the action on the track and the steadiness in running of the different types of locomotives having, for a given axle weight, a very low centre of gravity or a large proportion of unsprung weight.

5. — Coefficients of adhesion. — Data on the relative adhesive weight and tractive effort should be given to bring out the minimum coefficients of adhesion required for the different types of locomotives to be able to develop the effort corresponding to the hourly, the continuous and the maximum rating for a short period. The discussion could bring out the circumstances in which the coefficients of adhesion, in practical working, fall with certain locomotives to values appreciably lower than usual, while other types of locomotive, on the contrary, under the same working conditions, have higher coefficients. As regards lubrication methods, the results obtained with the different types of lubrication for the gears are very interesting.

Electrical part.

6. As regards operating the pantographs two ideas are followed :

a) The lift is by compressed air which, by means of a piston, puts into tension the spring holding the pantograph up to the overhead line. The pantograph is lowered by gravity.

b) The lift is by springs always in tension which give the required pressure against the overhead line. The lowering is by compressed air which counteracts the action of the said springs.

It would appear of interest to know the ideas of the administrations using the two systems mentioned, both as regards speed and ease of operation and as regards the safety of the staff.

As regards the pressure of the shoe on the contact line, a discussion on the various reasons the different railways had when fixing the values considered optimum, would be very interesting.

7. As regards *protection against overvoltage* it may be asked what are under present conditions the conclusions as regards the different arrangements considered indispensable for continuous current locomotives.

8. As regards *circuit breakers* required to open *automatically* by relays when the current becomes excessive or when the voltage exceeds a minimum or maximum value, two schools are followed :

a) Circuit breakers which cut off the current independently of the abnormal value of the current density or of the voltage and of the working of the sub-stations and feeders.

A discussion on the circuit breakers of alternating current locomotives of this class and on the different types and arrangements used to avoid explosions when oil is used, and a discussion on the results given by air breakers recently introduced, would be valuable.

As regards rapid and extra-rapid circuit breakers used on continuous current locomotives it is interesting to have confirmation that these breakers are the most suitable for protecting the gear against short circuits, and that the excess tension on suddenly breaking the current can be eliminated by suitable resistances.

b) Circuit breakers which in the event of a short circuit only open after certain others through the action of special relays.

In the case of alternating current locomotives the action of the relays is such that the locomotive circuit breaker in the event of a violent short circuit only opens after the nearest section breakers of the contact line.

For continuous current locomotives the relays only allow the current to be cut off after the intensity of the short-circuit current has been reduced by the insertion of starting resistances in the circuit.

As the two systems of breakers *a*) and *b*) are often used on the locomotives of an individual railway, it may be asked which is the better.

9. *Equipment.* — Seeing that opinions agree on the best system of equipment for continuous current and three-phase current locomotives, it may be asked which is the best equipment for single-phase locomotives (electropneumatic or electromagnetic contactors, cylinders operated by servomotors, etc.).

10. *Transformers and traction motors.* — The general question affecting all types of traction motors (tests to ascertain the power, heating, dielectric rigidity, etc.) are now under consideration by several committees so that they need not be dealt with at this Congress.

It may, however, be desirable to state the opinion expressed in the different reports that if on the one hand the continuous current, single-phase and three-phase motors recently built give satisfactory results as regards heating, commutation, specified power, it appears still necessary to consider improvements intended to reduce the defects in the insulation.

11. As regards the *safety of the staff* in service on electric locomotives it would appear desirable to adopt uniform regulations and arrangements in all countries. The discussion could therefore deal with the following points :

What are the arrangements to be provided to prevent the staff accidentally coming in contact with the current collectors and with conductors under tension ?

What arrangements are to be provided for the safety of the staff against explosions or fire of apparatus containing oil?

12. Although on the *electric locomotives intended to run at very high speeds* [above 100 km. (62 miles) per hour], the individual axle drive by gearing has been adopted in recent construction with raised motors rigidly fastened to the frame and four-wheel leading bogies, it may be asked if, for future building of this type of locomotive, the application of other systems of drive or single axle leading trucks is being considered.

13. As regards *regeneration of energy or electric braking*, every one agrees upon the importance of using one or the other system in order to increase the safety of the ordinary brakes on lines with heavy gradients.

The possibility of using regeneration or electric braking is always subject either to the advisability of not making the locomotive too complicated, or to financial considerations.

14. As regards the so-called dead man's handle more especially used on multiple unit trains, three types may be distinguished amongst those most used :

a) arrangements whereby the driver has to press a button or pedal all the time without causing the current to be shut off and the brakes to be applied;

b) devices as above mentioned, except for the difference that the action on the circuit breaker and the brake takes place after a certain interval of time previously determined;

c) devices as above, which come into action after the vehicle has travelled a certain distance regulated beforehand.

In view of the tendency to operate rail motor coaches or locomotives with a single man, a discussion on the different devices would be interesting, both as regards safe working and the comfort of the staff.

15. *Operation*. — The data on operation contained in the different reports is not enough for any general conclusions to be drawn therefrom, either on the mileage possible with the different types of locomotive between general repairs, or on the number of service defects arising during a given mileage.

It is however possible to affirm that the electric locomotive, as a result of the improvements made during the last years in the electric part, already gives better results both as regards mileage and regularity of service than the steam locomotive.

Supplement.

A report by Dr.-Ing. W. Wechmann [1] has been recently added to the reports already mentioned in the special report. This report which was received after the special report had been drawn up deals with the single-phase electric locomotives of the German State Railways. It contains many statements common to the other reports but, on the other hand, it also throws new light on certain other questions.

1. The results, quoted in Dr. Wechmann's report on the subject of two locomotives with the motors suspended by the nose and wheel arrangements 1 $C_0 + C_0$1 and 1 $D_0$1, which reach speeds of 110 km. (68.3 miles) per hour, are very interesting and add a fresh contribution to the questions asked in No. 2A of the summary.

2. Kleinow's modification of the drive of the Westinghouse type by hollow shafts and springs, mentioned in the report appears to improve the results given by this system of transmission.

3. As far as the electrical part is concerned, mention is made of new types of main oil-less circuit breakers, and this contributes appreciably to the questions

(1) See *Bulletin of the Railway Congress*, April 1930 number, p. 1309.

asked in Nos. 8*a* and 11 of the summary.

4. The system of equipment called « precision or fine regulation control » mentioned in the report differs from the other systems adopted for single-phase current locomotives in the fact that the control operations are carried out in a continuous manner and not in steps (question 9 of the summary).

5. As regards the transformers, a very interesting remark is made about the tendency to generalise the use of air-cooled types so as to avoid the use of oil and the resulting inconveniences (question 11 of the summary).

6. The report contains a summary of the improvements made in single-phase motors, especially as regards the commutation.

7. The report mentions the different arrangements that are being tried so as to make it possible to work a locomotive by a single man with perfect safety (question 14 of the summary).

[625 .25]

QUESTION VIII.

(ALL-STEEL COACHES. COMPARISON WITH VEHICLES BUILT OF WOOD) [1],

by Mr. LANCRENON,

Special Reporter.

This question has been dealt with :

For America, the British Empire, China and Japan [2], by Mr. E. J. H. Lemon, Carriage and Wagon Superintendent, London Midland & Scottish Railway.

For all countries except the foregoing and Belgium, France and Germany [3], by Mr. Martin Garcia-Varo, Engineer of the Andalusian Railway Company, and Mr. Pablo Fraile, Assistant Superintendent of Rolling Stock, North of Spain Railway Company.

For Germany [4], by Mr. E. Dähnick, Passenger Vehicle Designer at the Central Office of the Deutsche Reichsbahn Gesellschaft (German State Railway Company).

For Belgium and France [5], by Mr. Lancrenon, Assistant Chief Mechanical Engineer for Rolling Stock and Traffic, French Nord Railway Company, and Mr. Vallancien, Principal Engineer at the Central Office for the Study of Railway Rolling Stock at Paris.

The courtesy with which Messrs. Lemon, Garcia-Varo and Dähnick agreed to the plan of the questionnaire drawn up conjointly, and the similarity of our conclusions, have greatly facilitated the preparation of the Special Report, in which no distinction will be made between the conclusions of the different Reporters.

I. — General.

Utility of metal construction.

The first metal railway vehicles were built in the United States of America at the beginning of this century, and this method of construction rapidly became general on the American railways, because of the difficulties they had in obtaining suitable wood for constructional purposes.

The resultant increase in weight prevented for a long time other countries from following the same road, and, except for certain city and suburban lines, it seems from the replies received by the Reporters, that metallic construction has been seriously investigated in Europe during the last ten years only.

Advantages. — The recognised advantages of this method of construction are as follows :

a) Safety, owing to the shock resisting qualities of the stock, and the elimination of splintering of wood in cases of collision : also owing to the stock being fireproof;

b) Substitution of rivetted or welded joints for the old wooden construction; consequently better behaviour of the vehicles in service, and, as a result, greater comfort for the passengers;

c) Longer life of the stock and, therefore, reduction in maintenance and depreciation charges;

d) The use of steel, which can be manufactured in any quantity, in place of wood, the scarcity of which is already being felt owing to the destruction of the forests;

e) Mass production of standardised parts.

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(1) Translated from the French.

(2) See *Bulletin of the Railway Congress*, June 1929 number, p. 589.

(3) See *Bulletin of the Railway Congress*, September 1929 number, p. 1771.

(4) See *Bulletin of the Railway Congress*, February 1930 number, p. 635.

(5) See *Bulletin of the Railway Congress*, July 1929 number, p. 1023.

Disadvantages. — The following objections have been made to metal construction :

a) Increased tare weight of the vehicles, augmenting the cost of haulage;

b) The difficulty of protection against rust;

c) Conductivity of the body sides allowing variations in temperature to be transmitted to the interior;

d) Resonance of the vehicles;

e) Difficulties of interior decoration and fitting out.

The engineers have carefully studied these questions, and we see that, in general, they have found satisfactory solutions for the problems set, taking into account the special operating conditions on their respective lines.

II. — Types of vehicles in service.

a) Independent underframe, usually formed by a central, fish-bellied girder with brackets carrying a light framed body.

This method provides stock which stands up well in service, and is suitable for roads using central couplings. It further enables the interior fitting out of the body to be entirely subordinated to the needs of the passengers, but it has the drawback of increasing the tare weight materially, as the underframe alone has to take all the stresses without any assistance from the body framing.

It is the standard type on the American Railways, and has been adopted in Europe by the Sleeping Car Company.

b) Side girder type, in which the body frame also takes part of the stresses.

This is the best method for Railways who wish to avoid excessive tare weight.

When as a result of a collision one of two consecutive coaches of this type mounts the other, there is no reason to fear the disastrous effects attendant on the telescoping of a rigid frame into the body of the next coach.

The problem of the metal girder has been variously treated, from the lattice girder of the German, Spanish, Dutch and Japanese coaches, as well as of the coaches designed for certain French lines by the Central office for the Study of Railway Rolling Stock, to the veritable partitioned tube form of the carriages of the Italian State Railways, of the London Midland & Scottish Railway and the London & North Eastern Railway of England, and of the French Nord and Est Railways.

III. — Material, and methods of construction.

Material. — From the replies received, it is evident that the builders have used in very varying proportions, according to the local supplies available, and the quality of the labour at their disposal :

Flat sheets, bent and pressed;
Rolled sections;
Malleable iron or steel castings;
Light alloys;
Special steels,
and even wood.

The rolled sections are easily obtained : the use of bent and pressed sheets lightens the construction but their manufacture calls for specialised labour and costly tools.

Malleable castings are used along with wood between the sides.

Cast steel is used for parts which have to resist shock, and specially for the frame end and the bogie bolster.

Light alloys are already in general use.

Aluminium sheet is very suitable for inside panelling. Alloy castings are also being used for the manufacture of folding and swing doors, net rack brackets, name plates, and for other interior fittings.

Special steels are still very little used on account of their high price. The Lon-

don Midland & Scottish Railway however reports the use of high tensile steel for the underframes of their electric motor coaches.

Assembly. — This is effected by round-headed, or countersunk rivets, by oxy-acetylene welding, by arc or spot welding.

The use of the two latter methods is extending with the improvements in the tools at the builders' disposal, and trials for strength carried out on units assembled by welding show that a well made weld gives the same guarantee of safety as rivetting.

Protection against rust. — The use of iron and copper bearing steel appears to be coming general.

All the lines recommend a thorough removal of scale by sand blasting before putting on the first ground coat. The American lines use very largely paints stoved at high temperature. Elsewhere ordinary varnish paints, or cellulose paints are preferred.

IV. — Fittings.

Use of wood. — As regards interior fittings there are two opposite schools : Should the compartments be partitioned and panelled in wood, or should its use be forbidden ?

Wood is more pleasant to look at and to touch. It is a good insulator, is non-resonant, and does not sweat, but it does not harmonize with the metal structure which it masks and, in case of accident, through splintering it might cause wounding.

My reporter colleagues seem to prefer fittings in wood, which, says one of them, prevents passengers from seeing that they are in a metal coach. For my part I can see nothing but advantages in showing the public the safety which the railways are trying to secure to them, often at great expense.

Thermal insulation. — From the information given it would seem that insulating linings (cork packing, felt, etc.) and air spaces between the walls, stop heat radiation through the metal sides. None the less, it is advisable to provide for metal coaches from 30 % to 40 % greater heating service than that adopted for carriages with wooden bodies.

Resonance. — In service metal coaches have been found nearly noiseless, because of the thermal precautions taken and the rigidity of construction.

Concrete flooring on corrugated sheets leaving something to be desired from this point of view, numerous trials have been made to remedy the defect, and we find in Mr. Lemon's report a very interesting statement of the solutions adopted.

Decoration. — The interior appearance of carriages lined out in wood does not differ from that of the earlier designs. On the other hand we have seen an entirely satisfactory scheme of decoration for a carriage in which the whole of the interior panelling is of metal.

Lavatories. — The documents published in the reports show that the railways are actively concerned in providing the public with very comfortable and hygienic installations. This question is, however, outside the problem of metal construction.

V. — Comparison with wooden carriages.

Comfort. — The experience gained shows that when all necessary precautions have been taken to insure quiet, insulation, heating, and ventilation, metal coaches offer the public a comfort equal, and even superior, to that of coaches with wooden bodies.

Safety. — Observations made in the case of collisions which have taken place in recent years show that the safety ex-

pected was not illusory, and the photographs published in the individual reports confirm this.

What price have the railways had to pay for these advantages, both as regards weight and first cost ?

Tare. — To compare properly the tare weights arrived at by the different railways, disregarding the question of overall dimensions and interior fitting out peculiar to each country, we will compare only main line stock and their tare per square metre (per square foot) of floor space.

	Weight in kilogrammes per square metre (in pounds per square foot) of floor space.			
	All metal coaches.		Coaches with wooden bodies.	
	Kgr.	Lb.	Kgr.	Lb.
Argentine Republic	700-750	143-153	650-700	133-143
China	1000-1 200	205-246	700-900	143-184
United States of America	850-1 200	174-246	800-1 000	164-205
Great Britain	700-800	143-164	650-750	133-153
Africa	600-900	123-184	500-800	102-164
Australia	675	138	800	164
India	550-700	113-43	550-700	113-143
Japan	650-950	133-195		
Egypt	872	179	890	182
Spain	750-800	153-164	400-750	82-153
Holland	700-950	143-195	780	160
Italy	775	159	700	143
Poland	795	163	790	162
Rumania	750-800	153-164	760	156
Switzerland	750-800	153-164	750	153
Czechoslovakia	770	158	730	150
Yugoslavia	780	160	690	141
France	750-800	153-164	700-750	143-153
Germany	800-875	164-179	800-925	164-189

If one bears in mind that the metal coaches recently built have the latest improvements introduced into coaches with wooden bodies, and may be compared to the heaviest of such type of coach, it will be found that the increase in tare weight is in many cases less than 5 %. In Germany, the metal structure is even in certain cases lighter than the wooden.

Cost. — The methods of construction are still too varied, and on many railways metal coaches have been put into service too recently, to allow of a very definite opinion regarding the increased cost resulting from the use of metal construction, and as to the reduced cost of upkeep. No report is definite in this respect.

Though the reduced costs of upkeep and depreciation may not entirely offset the higher first cost, it may be concluded that the increased safety has been acquired without prohibitive expense.

Stock. — The position as regards all-metal vehicles in the different countries is as follows :

U. S. A.	27 000
Germany.	10 253
France	3 000
Italy	1 300
Canada	850
Japan	650
Great Britain	600
Australasia	250
Egypt	170
Argentine Republic.	150
China.	100

CONCLUSIONS.

As a summary of this paper we propose the following conclusions :

1. Considerations of safety are in themselves sufficient to justify the use of metal construction for coaches to be built.

2. Metal coaches can be fitted up so as to assure to the public a degree of comfort equal, and even superior, to that of vehicles with wooden bodies.

3. To prevent excessive tare weight, it is desirable that the body should take part of the stresses.

Coaches built on this principle are very little heavier than coaches with wooden bodies offering the same standard of comfort.

4. In this form of construction it is possible to combine rolled sections, bent and pressed flat plates, cast steel and malleable iron castings.

In every way metal construction lends itself to the mass production of standardised parts.

5. Assembly can be done by means of rivetting, oxy-acetylene welding, arc or spot welding, or by a combination of these methods.

6. The interiors can be fitted out in the same way as wooden vehicles. They can, however be given a new appearance, if the metal plates are left visible and the interior decoration treated accordingly.

7. The methods of construction are still too varied and the vehicles on numerous railways have been put into service too recently to allow precise conclusions to be formed regarding the first cost of construction, and the repair charges.

8. Numerous experiments have still to be made both as to the choice of the methods of construction and the materials to be used, as in fitting out the interior, such as the insulation of the body sides, the floor covering, interior linings, painting, and protection of the plates against rust.

[656 .213]

SECTION III. — Working.

QUESTION IX.

(RELATIONS BETWEEN RAILWAYS AND SEAPORTS),

By C. M. JENKIN-JONES,

Special Reporter.

This subject has not been considered by the Association previously and for this session three separate reports have already been printed and circulated (1) (2) (3). A large number of Railway Companies have replied very fully to the questionnaire, and the Reporters wish to express their appreciation of the care and trouble that has been taken by the Railway Companies in answering the questions so fully.

From the replies received it may be possible to form an opinion as to the trend of port development in respect of the lay-out of the railway facilities, and of the arrangement and equipment of the docks and quays. Information has also been collected regarding the methods of working and charging traffic at sea ports.

The list of questions submitted to the Railway Companies was drawn up by the Reporters on quite general lines, and some of them are capable of being read in more than one sense. In a few instances the replies shew this divergence. This has not detracted from their value; it has indeed rather added to the interest of the enquiry.

It is noticed that in each instance the three Reporters have decided to consider the subject in detail only so far as important harbours are concerned. This selection was to be expected, and it is therefore proposed to limit the résumé of these reports similarly.

On this understanding each of the main headings of the Questionnaire will be taken in turn and it is proposed to indicate what may be considered the best and most recent practice as regards the lay-out and equipment of large sea ports and their railway connections, and to indicate what are the prevailing methods of procedure with regard to tariffs and organisation.

Railway yards at large ports.

It is the general opinion that for miscellaneous export and import traffic the most efficient arrangement is one which concentrates the traffic to and from the port in one locality which should be reasonably near the harbour wherever this is practicable. By doing so it is possible to centralise the supervision of arriving and departing trains, and the arrangement for the distribution

(1) Report No. 1 (all countries except America, the British Empire, China, Japan, Belgium, France and their Colonies), by Messrs. Ehrenfreund and Belmonte. — *Bulletin of the Railway Congress*, July 1929 number, page 1093.

(2) Report No. 2 (America, the British Empire, China and Japan), by Mr. C. M. Jenkin-Jones. — *Bulletin of the Railway Congress*, October 1929 number, p. 2257.

(3) Report No. 3 (Belgium, France and their Colonies), by Mr. U. Lamalle. — *Bulletin of the Railway Congress*, February 1930 number, p. 535.

of laden and empty wagons in both directions. It also permits locomotive depots and wagon repair sidings and shops to be concentrated and placed in close proximity to the harbour, and in this way reduces to a minimum the light running of the engines and uneconomical movement of wagon stock.

It is rarely the case at large ports that the marshalling of trains of inward traffic and the assembly of outward train loads can be done at different periods of the day. It is therefore considered that the yards for inward and outward traffic and the lines leading to and from them in each direction should be adjacent to, but independent, of one another.

If the port is served by several railway companies it does seem necessary to provide separate yards for each of the companies. It is generally considered that to ensure maximum working efficiency the traffic between the port and the various railways serving it should be assembled in a single concentraction yard. This is always supposing that the volume of traffic is not greater than the yard can accommodate.

Geographical features necessitate variations in this arrangement. For example, at ports which have quays or docks widely separated, or where the available land space precludes such a concentration of sidings as is needed to carry on the whole business of the harbour. In these instances it may be necessary either to have several yards or the inward and outward yards in different quarters of the port.

An exception to the concentration of the whole of the port traffic in a single yard must be made at places where the port has quays at which large volumes of special traffics are catered for, and which are led to and from the port by train services that are distinct from the ordinary general traffic services. For example, where large quantities of coal or ore traffic are involved it will generally be found advantageous to provide a separate yard exclusively for the assembly, sorting, and despatch of wagons containing these commodities. They usually pass in full train loads from the collieries or mines in the case of exports, and between the port and the consuming points in the case of imports.

The inward and outward concentration yards should be capable of holding considerably more traffic than the ordinary normal working conditions require. This is necessary in the outward bound direction in order to provide for the vagaries of the shipping which are influenced by seasonal requirements, stormy weather, fog, and the uncertainty as to the date of arrival of ships; and in the reverse direction in order to allow the ships to continue discharging when the railways are unable to work the traffic away as it arises due to congestion, accident or other exceptional circumstances.

The design of port yards differs very little from that of ordinary railway terminal or through yards, except in amplitude. The nature of the shunting work is similar in both cases. If the port yard is located in the vicinity of a large centre of population there is no particular reason why one yard should not be used for the purposes of both the city and the port, provided that the total traffic does not exceed the economic working maximum of a single yard.

Lay-out of concentration yards.

The most modern lay-out of a yard such as the one already mentioned provides for ample train reception sidings in order to receive the traffic from the main lines and the port as quickly as trains arrive.

From these lines the wagons are shunted by gravity or by propulsion over a hump into a main group of sorting sidings into which the wagons containing export traffic can be separated for dock or quay, for shed lines, or for

storage sidings or storage grounds; and in the opposite direction into train destination order. From these sidings the wagons may be still further sub-divided by similar means in another group of sidings into berth or other order. It is desirable that wagon movements should be continuously in the direction of their final destination.

Although a port yard of the character described can be designed to marshal up to four or five thousand wagons per 24 hours if necessary, additional groups of sidings near the quays are essential to ensure prompt service at the ship's side or at the storage or transit shed. The arrangement of these sidings will vary with the design of the quays and the jetties at the port, and should be placed as near as possible to the quay lines and transit shed lines so that continuity of service at the ship or shed may be maintained. These lines should be laid out so as to be used for traffic either to or from the ships or sheds, and the arrangement of the connections between them and the loading lines at the ships or sheds depends on whether the work is performed by shunting engines and capstans or by capstans and turntables or traversers.

Shunting power.

The general practice is to make movements by shunting locomotives between the groups of sidings and the shed and quay lines, and also for marshalling wagons into hatch or destination order. The final movement of wagons to a crane or ship's derrick is usually done by electric or hydraulic capstans or in some cases by petrol driven towmotors; if the latter machines are used the top of the rails must be sunk to the general level of the ground.

Disposal of discharged wagons.

Wagons which have been emptied at the port and which are not prohibited on account of ownership or unsuitability from being re-loaded are generally placed in position for re-loading with the minimum of movement from berth to berth or quay to quay, and only the prohibited wagons and surplus wagons are returned empty to the concentration yard for despatch to inland loading points.

Separation of consignements en route.

The separation en route of wagons containing goods for export by the same ship is undesirable and it is generally the practice to keep such wagons together throughout their journey wherever practicable. Where traffic for one ship is despatched in full train loads or in large quantities arrangements are very generally made to ensure that successive consignments follow at close intervals and in time to prevent interruption to the loading.

Wagon detention.

There is considerable variation at different ports in the methods adopted to obtain the prompt discharge and loading of wagons, and also in the charges raised for wagon detention. At some ports there are no definite regulations, in other cases the forwarding of traffic is regulated by arrangement, fixed quantities being allowed to come forward daily and in such cases, if these quantities are not exceeded, no demurrage charge is imposed.

In other cases wagons are not supplied to inland loading points, nor are they removed when loaded until the ship for which they are intended is known to be within a pre-determined number of hours from the port.

Before demurrage is charged a free period is allowed. This varies from 6 hours to 15 days from the date of arrival of a wagon at the port carrying export traffic, and there is generally a short free period before a detention charge

is raised on an empty wagon supplied to a ship for loading. The charges in some instances are graded upwards as the period of detention increases.

Quay arrangements.

Sea ports may be roughly divided into three general types :

1. Open harbours on or near the sea coast protected by breakwaters from the range of the sea. Such harbours may be tideless as is the case of the Mediterranean ports, or tidal as is the case of estuarine or river harbours.

2. Ports consisting of docks which are open for a short period before and after high water and in which the depth of water is approximately constant.

Vessels can enter or leave such docks at all times if a lock pit is constructed at the dock entrance.

3. Quays and open basins on rivers where the port is at a distance from the sea and where the tidal variations are unimportant.

Combinations of two or more of these types are common in individual harbours.

The employment of a combination of long riverside quays and inner open basins is frequently adopted in order to concentrate the working of the port over an economic working length.

If the harbour is an open one and on an estuary, a river, or on the coast line, the most economical arrangement from a constructional point of view will generally be found to be a long quay parallel to the fairway, provided the total length required can be confined within reasonable limits.

Failing this it is the common practice whether the harbour is enclosed or open to construct a series of parallel jetties projecting into the open harbour or the enclosed dock. The most convenient concentration of the land services and an economical use of the available water space is attained by this arrangement.

If this plan is adopted there should always be an adequate width of water space beyond the ends of the jetties for manœuvring ships when approaching or leaving the berths. The space needed is greatest when the jetties are at right angles to the direction in which the ships approach or leave the berths.

It seems to be quite a frequent practice to arrange jetties at an obtuse angle to the fairway, the basins being inclined down stream or in the direction of the approach of shipping. This allows of easy access from the sea and permits the railway lines to be laid in with curves of ample radius.

The dimensions of the jetties and water space between them are dependent upon navigation and railway requirements. If the jetty quays provide for a number of ships berths the waterways must at least be of sufficient width to allow ships and tugs to pass freely to and from the inner berths clear of ships lying alongside the quays. Space should also be provided for lighters and other craft to lie alongside the ships in the berths while they are discharging or loading.

If the jetty basins are very long the width of the waterways may be diminished in stages from the open water and the quays will then be in the form of steps which is a convenient arrangement for railway working. Such an arrangement, however, does not permit the maximum use to be made of the quays as it presupposes a more or less uniform length of ship.

An arrangement of T headed piers projecting in front of one another is found to be convenient for ships taking bulk traffics by special machinery as the ships can be overlapped and quay length is thereby economised.

General cargo jetties must be of sufficient width to allow at least three

working lines along each quay and the necessary feed and working lines, transit sheds, or storage grounds between them. The nature of the business carried on at each quay determines the amount and kind of accommodation that is required in individual cases.

Switching arrangements

The use of turntables and traversers for transferring wagons from track to track is very generally avoided when laying out modern quays and the transfer of wagons is almost exclusively done by means of switches.

By this arrangement rakes of wagons can be shunted into position and withdrawn by locomotives very rapidly and the service at the quaysides can be carried out continuously throughout the port working hours.

An additional advantage obtained by the use of switches in preference to turntables or traversers is that exceptionally long wagons or a long load carried on a series of wagons can be readily transferred from one line to another.

It will be seen from a perusal of the reports that by a careful arrangement of switches and railway quay and shed lines interruptions to loading and discharging of wagons and ships can be reduced to a negligible quantity.

Sheds and warehouses.

Sheds and warehouses on the quays vary in construction and internal arrangements, according to the nature of the traffic and as the custom of each port demands.

When the sheds are used for examination, re-conditioning or sorting the traffic passing through them on its way to and from ships, it is often convenient to construct the sheds with a floor at the level of the wagon bottoms when the goods can be handled between ship and shed by crane.

When the goods moving between ship and shed have to be barrowed between the quay crane and the transit shed, the shed floors may with advantage be sloped up from the quay level at the ship side of the shed to the level of the wagon bottoms at the landward side. This can only be permitted, however, when the sheds are of a considerable width, otherwise the slope of the floor would be excessive. Power worked barrows and runabout road cranes can be used with advantage at many places.

For sorting traffic within the sheds, overhead high speed bridge travelling cranes are economical and convenient.

Warehouses on quays in which goods are held for long periods are usually built in several stories each of which may be equipped with power worked lifting and travelling appliances, which should be arranged so that one or two lines of wagons at each side of the sheds may be loaded or unloaded direct from each storey.

Railway lines are frequently laid inside the ground floor of the warehouses, but it would seem to be an unnecessary waste of the area of the warehouse floors if lifting apparatus is available which will serve both the outside shed lines and also distribute the goods on the shed floors as desired.

There seems to be an increasing tendency to move shipping traffic direct to and from the ships sides by road motor vehicles. It would appear, therefore, that the advent and increasing use of heavy mechanical road transport may make it necessary in the future to modify the lay-out of the roads and railways in and around harbours.

Unloading and loading equipment on quays

The type of appliances needed for the rapid handling of cargo depends entirely

on the nature of the traffic. Highly specialised machinery is needed for bulk traffics such as fuels, ores, grain and liquids.

The specialised machinery for shipping bulk commodities are described in some detail in the three reports submitted and it is not proposed to refer to them in detail in this special report.

Quay cranes.

For general cargo, cranes are necessary and there are a variety of types. They should in all cases be designed so as to permit of the free and uninterrupted movement of wagons along the quays. They should have sufficient reach to plumb the wagons on the quay tracks as well as the outside benches of the sheds nearest the quays, and they should at least be able to reach the side of the ships hatches furthest away from the quay.

The foot of the jibs should be sufficiently high to allow the jib to clear the superstructures of the ships, and in order to allow two cranes to work simultaneously at one hatch, cranes of the level luffing type are necessary and have other advantages.

It is evident that cranes of a greater lifting capacity than the weight of the majority of the lifts normally made at the quay will prove costly to work. In order that occasional heavier lifts than normal may be made, the cranes should be geared to two speeds, the speeds being in proportion to the lifting capacities. If dual capacity cranes are used it will generally be found that 3-ton cranes with 1 1/2-ton high speed lift will deal satisfactorily with ordinary general cargo.

With the increasing demand for quick despatch of ships and the increase in the number and size of ships hatches, the provision of five or more cranes is desirable at each general cargo berth.

One or more of the cranes at each berth may with advantage be of a higher capacity than the remainder of the cargo cranes so that the occasional heavier lifts offering may be made without moving the ship from its moorings.

The actual capacities of the cranes at the berths can only be determined by the needs of each port.

For lifting exceptionally heavy articles, floating cranes are usually found to be the most serviceable machines. The provision of cranes of this kind depends largely on the frequency of the lifts for which they would be used, and also as to whether there is sufficient space in the waterways at the berths to allow the cranes to be brought alongside.

Methods of port working.

Ports may be owned by a railway company, by a city, by a municipality, by a private company, or by a combination of interested parties. The method of working the port remains fundamentally the same whether it is owned by the railway company serving it or by a separate port authority.

In either case it seems to be usual for the work of unloading or loading from or to ship to be done by stevedores employed directly by shipowners. Nor does it seem that a port authority often undertakes the haulage of wagons on the dock property. This is usually done by the railway company, on terms which will be explained later.

The day to day work of an independent port authority is concerned rather with the regulation of ship movements in the dock.

Where the port does not belong to the railway company serving it, the arrangements for the despatch of traffic are usually made either by the shipping agents or by collaboration between the port and railway personnel, or by a committee of management who works the port and control the staff.

The railway company regulates the

flow of traffic when necessary in consultation with the shippers or agents in order to avoid congestion or a waste of rolling stock.

If a port is owned by an independent port authority a line of demarcation has to be drawn between the functions exercised by the railway company in its sphere of transport agent, and those exercised by the port authority or, it may be, by the railway company acting as its agent.

A lack of uniformity in the division of responsibility will naturally result in differences in the methods of dealing with wagons and these differences have been revealed in the replies to the Questionnaire.

Whether the railway company serving a port bears the initial cost of the railway installations varies according to the ownership of the port. Where it was built and owned by the railway company the cost was borne by that company; were it was owned by a separate authority, the railway company only bore the cost of installation up to the point where the ownership of the port authority commenced.

Apparently it sometimes happens that a railway yard for dock traffic is constructed on the initiative of the port authority and the expense is then borne jointly.

The practice of regarding the concentration yard as a part of the installation also varies without any clear reason for the variation being evident. Where a port is owned by a separate authority, there seems to be a tendency on the part of the railway company to combine in one yard the marshalling of dock traffic and of traffic for the town and neighbourhood. Where a port is owned by the railway company and is quite distinct from any town, the concentration yard is regarded as part of the installation.

Tariff arrangements

It seems to be the general practice that the rail rate charged to a trader who forwards traffic for export covers in addition to the actual conveyance, the services necessary to take the wagon alongside ship, but that the services incidental to transferring the traffic to or from ship are charged for separately, either by the port authority or (in the case of a dock owning railway company) through separate dock accounts. The reason presumably is because at the time of forwarding it is not known precisely what these incidental services may be. Any variation from this practice seems to be in the nature of an exceptional arrangement; there are, for instance, a small number of through rates — particularly where the railway company owns the steamships — covering rail transit to the port, dock charges, and sea transit to another country, but it is not usual for rates to be made up on this basis and placed on the railway company's rate books. It is more usually the shipping agent who gets quotations of the component rates and combines them into a through rate for his client.

It should not, of course, be assumed that when the trader has paid the rail rate to a railway company and the wharfage and shipping charges to a port authority the final division of receipts between these two has been made.

It has been explained that the rail rate normally takes the traffic alongside ship, that is to say, where the dock is not railway owned, into the territory of the port authority. In such cases there will be an agreement between the railway company and the port authority by which the former makes an outpayment to the latter of the due proportion of its receipts from rail rates, after taking into account any services performed by either on behalf of the other.

The principles on which import and export rates are fixed are, on the tra-

ders' side, a desire to have rates which will enable them to compete successfully in world markets, and on the railway company's side, a desire to stimulate trade and, in some instances, to induce traffic to pass through a port served by itself rather than through a competing port which it does not serve, or to secure traffic from an all sea route or other competitor.

The actual tonnage and frequency of traffic does not, therefore, exercise supreme control over the level of rates, although the fact that certain traffics for export are forwarded in large consignments enables exceptionally low rates to be given which yet yield the railway company an economic return. The level of import rates is influenced by the policy which a country adopts for the protection of its home industries.

General conclusions

It is difficult to formulate definite conclusions on the subject of this enquiry.

Many of the ports in the Old World were originally constructed to meet military and naval requirements, and the sites selected for these purposes were very often at the coastal terminations of overland trade routes.

The sites were chosen so as to make the utmost use of the natural features of the land affording safe harbourage for shipping. They generally were conveniently situated in relation to the important centres of population. The selection of the sites of these ports influenced or was influenced by the ancient overland trade routes and, once having become established, custom has continued their development on the original sites.

As trade developed in other countries with the spread of civilisation, new ports were opened, and advantage was still taken of localities which provided natural harbourage and they gradually became gateways for trade.

It is only within comparatively recent times that the construction of harbour works of any extent has been undertaken, and even in these cases the first object of the works was to protect the shipping, little or no regard being given to the nature or suitability of the access on the land side.

With the introduction of railways they at once began to cater for the trade of established ports, and with the rapid growth in the size of ships and the volume of sea borne trade, many of the old harbours are now found to be located where the area and contour of the land available for railway purposes is unsuitable.

In addition to the difficulty in finding room for convenient railway approaches to these ports, the railway installations at first laid down were naturally of meagre proportions. As trade increased the growth of the population of ports so surrounded and hemmed in the railways that expansion is now found to be difficult and costly. This has made it necessary in a number of cases to separate the railway installations from the neighbourhood of the port in order to provide for the expansion of the traffic.

The rapid development of sea borne trade during a comparatively short period has thus resulted in conditions at the older ports which are far from ideal.

Bearing in mind the history of ports and the development of land transport, it is astonishing to find how successfully primitive arrangements have been adapted to meet the enormous increase in volume and the demand for quick despatch of traffic.

The Reporters feel some diffidence in offering any conclusions which may be drawn from their examination of this subject. In doing so, however, it is only intended to indicate what seem to be the general lines which should be followed in order to improve existing installations,

and to suggest in outline desirable features that should be embodied when harbour works are being planned. These suggestions, it is thought, will perhaps provide a basis for discussion at this session.

Our conclusions briefly are as follows:

The harbour station.

1. One harbour concentration yard is preferable where the traffic is of a general nature and comes to the port from all directions and the volume of traffic is within the capacity of a single station.

Several concentration yards are permissible when certain traffics are worked by train services entirely distinct from the general service.

2. The stations should have separate groups of sidings and running lines for inward and for outward traffics.

3. The yard should be sufficiently large to take up the repercussions due to temporary cessation of traffic movements in either direction.

4. The concentration yard may be used for shipping, local, and through railway traffics so long as the limit of capacity of a single yard is not exceeded.

5. The shunting may with advantage be concentrated in the harbour station and the shunting at the quays limited to sorting to hatches and destination order when loading direct to ships, or to shed or warehouse bench order.

6. Ample holding tracks should be provided at the quays to ensure continuity of service at the ships or sheds.

7. Wagons discharged at the quays should not be passed back empty to the concentration yard provided they can be re-loaded at quays to which they have ready access.

8. Consignments for export should not be split up en route unless the traffic is passing in such volume that continuity of loading can be maintained.

9. The lay-out of harbours should permit of the adoption of easy railway curves, 6 chains being considered to be the minimum permissible.

10. Adequate room should be provided at quays for the movement of ships, and also on the jetties for the necessary quayside and middle tracks, and for the sheds and shed lines. The sheds and tracks should be laid out so that interruption to loading operations during shunting movements is reduced to a minimum.

11. There should be at least three tracks alongside the quays with crossings at intervals in order to give the best working facilities.

12. Switches should be used generally and are preferable to turntables or traversers for shunting purposes.

13. At quays where road vehicles are largely used, quay tracks with grooved rails sunk to the ground level are convenient, and this arrangement permits tow-motors to be used in place of ordinary locomotives for shunting duties.

14. The capacity of quay cranes should not exceed the weight of the bulk of the articles to be lifted. Dual capacity cranes are economical and provide for occasional lifts that are heavier than normal. Cranes should be arranged to give free movement of wagons along the quays and to have sufficient reach to plumb the wagons on the quay lines and the further side of the ships hatches.

Cranes of the luffing type have many advantages.

High capacity floating cranes are considered to be the most satisfactory means of handling heavy lifts.

For loading and unloading wagons and sorting and storing traffic in sheds and warehouses, travelling bridge cranes fitted with revolving jibs which can be projected through the shed sides over outside wagon tracks efficient.

The number of quay cranes per berth is considered to be as important a con-

sideration as the determination of their capacity. The number should not be less than the normal number of hatches in vessels regularly using the port.

15. In order to reduce wagon detention, the demurrage regulations should be as severe as traffic working and labour conditions permit in order to guard against congestion at the port and to conserve the railway wagon stock.

16. The organisation of the staff working the port and the railways and the customs is of the greatest importance and should be such that the services can proceed smoothly and rapidly.

Finally, the desirability of close colboration between the railway companies and the port authority, when alterations, additions, or new harbours are contemplated, cannot be too strongly stressed.

[625. 258 & 656 212.5]

QUESTION X.

METHODS TO BE USED IN MARSHALLING YARDS TO CONTROL THE SPEED OF VEHICLES BEING SHUNTED AND TO ENSURE THEY TRAVEL ON TO THE LINES IN THE VARIOUS GROUPS OF SIDINGS),

By C. R. BYROM,
Special Reporter.

The object of this special report is to summarise briefly the main features and conclusions contained in the reports presented on this subject by Messrs. Pellarin and Farenc jointly (for France, Italy, Spain, Portugal and their Colonies (1); by Mr. C. R. Byrom (for America, the British Empire, China and Japan (2) and by Mr. Fiala (for countries other than the above) (3).

In my report, I mentioned that the title of Question X gave rise to a certain amount of speculation as to how large a field it was intended should be embraced and I recalled that at the London Session, in 1925, the question of « Shunting yards » was considered. One of the conclusions reached thereat was that the speed of wagons during gravity or hump shunting should be capable of being reduced as and when required, and that various methods of carrying this out were in use such as shoe brakes, braking rails, etc.

I also stated that some uncertainty existed in regard to the interpretation of that portion of the heading which reads: « to ensure they (the wagons) travel on to the lines in the various groups of sidings ».

It seems to me that the real object of Question X is to discuss the development of car retarders or rail brakes, and shoe or slipper brakes — in other words, the application of more scientific and economical methods to the principle of gradient or hump shunting. The reports submitted leave no doubt that this is the main part of the subject, but inasmuch as the practice and equipment differs in various countries at marshalling yards where rail-braking or mechanically operated shoe braking methods have not yet been instituted, I dwelt in my own report at some length upon non-rail braking practice also.

The second part of Question X has proved capable of two interpretations, one, point or switch operation and signalling, and two, means of propulsion, and I will deal later with both these features so far as information in the several reports is available.

Some very interesting data is revealed upon the whole subject, which is one that had exercised the minds of railwaymen and others for very many years with the object of finding some equally or more efficient, less costly and, in

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(1) See *Bulletin of the Railway Congress*, December 1929 number, p. 3059.

(2) See *Bulletin of the Railway Congress*, June 1929 number, p. 715.

(3) See *Bulletin of the Railway Congress*, August 1929 number, p. 1277.

some instances, safer means of performing the shunting at gravity (including hump) shunting yards, particularly that portion of the work which consists of controlling the speed of vehicles.

In many countries the introduction of new methods is largely in the development or experimental stage, although in the United states for instance electrically operated or electrically controlled rail braking or car retarding apparatus would seem to be an established principle. In France and certain other countries, it is true that much pioneer work has taken place for many years past, resulting in the introduction of a variety of rail braking or shoe braking methods.

Before commenting upon the rail braking and shoe braking features and other conclusions brought out in the various reports, I think it will be well to record very briefly several features appertaining to some of the different countries which will perhaps result in a better appreciation of the fact that the problem does not present quite the same universal aspect.

These relate largely to rolling stock. In the United States, a country of long distance hauls, the vehicles, generally known as « cars » (open and covered) are comparatively large. In Great Britain, where the average length of haul is short, the wagons and vans are comparatively small.

The average capacity of cars in the United States is about 40 English tons and of wagons, in Great Britain, about 12 tons. Generally speaking, the vehicles of all other countries on the average are of capacities ranging between those of the United States and Great Britain.

In the United States, cars are each fitted with a brake manipulated by a wheel at the extreme height of an open or covered car, and where distant braking methods have not been introduced, a man (known as a « car-rider ») accompanies, in fact actually rides upon, a car or cut or raft of cars over the hump or down the gradient until a state of rest is reached. Thus a large staff of car-riders has to be employed.

British wagons and covered vans are all equipped with a hand brake operated from ground level by an employee known as a brakesman, or wagon steadier. Wagons or vans, or cuts of these vehicles, are accompanied as necessary by a steadier or brakesman running or walking alongside and brake pressure is only applied to the extent and for the distance needed to avoid too great collision with vehicles already standing in the sidings. Comparatively few of these men have to be employed as compared with car riders in the United States. This is the general practice, as there is only one yard in Great Britain (Whitemoor, London & North Eastern Railway) fully equipped with rail braking methods, and the use of portable shoes or skates on the rail is rare.

Practice in other countries varies considerably. Some administrations do not possess any hump or gravity shunting yards, but where that method is employed, the simple shoe or skate placed on rails as necessary finds a more general use. The equipping of vehicles with hand brakes varies in extent. In France and other European countries a number of rail and shoe brake devices of different types exist, which are described in the various reports.

I will now deal with the first part of the heading and the individual reports.

I. — Controlling the speed of vehicles being shunted.

a) *Producing the speed required.*

This is obtained, in flat shunting, at practically all large yards, by means of a locomotive which « loose shunts » or « knocks off » the vehicles into the various sidings from a shunting line or neck, but inasmuch as the engine has to reverse and return beyond one or more

sets of points between each cut or operation it is obvious that the same speed of working cannot be obtained as in gravity or hump shunting. It is not proposed therefore to elaborate further on flat shunting methods, especially as it is considered the report is intended to relate more particularly to gravity shunting.

Continuous gradients, i. e., falling from the entrance to the reception or arrival sidings into the sorting sidings and without a hump or with a small hump or eminence, appear to be in the minority as they are dependent largely upon the configuration of the land being suitable or readily adaptable to provide the whole of the varying gradients required.

The provision of a hump of suitable gradient is the more general practice in gravity shunting and a propelling locomotive pushes the wagons, cars or cuts over the hump, suitable colour-light or other signalling arrangements controlled by the man in charge of operations at the hump being necessary to control the speed of propulsion.

The character and length of the gradient beyond the apex of the hump were mentioned in question III, at the 1925 Session (Shunting yards), and the conclusion reached was that the slope should be such that whatever the running condition of the wagons, and whatever the atmospheric conditions, sufficient speed should be attained to enable them to reach the maximum length of the sorting siding, braking power being provided to reduce speed as, and when, necessary.

Provided, therefore, that adequate braking power is available, the length and character of the fall from the hump must be governed by the nature of the layout of the sidings, their length, curvature, prevailing atmospheric conditions, weight of the vehicles generally, method of lubrication of axles, etc.

If braking apparatus is insufficient in power or number of appliances, to fulfil the maximum demand, then the slope of the hump requires modification accordingly, and any vehicles not attaining the desired length of run will require to be propelled further by locomotive or other means.

b) *Regulating the speed according to circumstances.*

The means adopted for reducing the speed as and when necessary, of vehicles after leaving the summit of a hump, resolve themselves broadly into the following general headings :

1. Hand operated brakes fixed to the vehicle and applying pressure on the wheels.

2. Shoe or slipper brakes or skates consisting of a metal shoe which rides on the track or running rail, the wheel of a vehicle mounting the shoe on coming in contact with it.

3. Rail-brakes consisting of lengths of metal parallel to the running or track rail, capable of applying pressure to the sides of the wheels.

In regard to (1), hand operated brakes are fitted to all vehicles in certain countries as previously explained, and, therefore, such vehicles require direct personal accompaniment during some portion of the entire movement after leaving the apex of the hump. For this direct contact, staff has to be provided and it is largely to curtail the personnel and thus reduce costs, that new means of achieving the desired result of braking are sought.

With respect to (2) this can be divided into two heads. Firstly, the simple portable shoe or slipper, in fairly general use in some countries, and which is placed on the rail by an employee in advance of a vehicle moving too quickly. At the conclusion of the operation the shoe has generally to be carried manually back to the spot required. Obviously, this method requires an appre-

ciable number of personnel, according to the density of work. Efforts to reduce this staff and the consequent costs bring us to the second point.

This embraces the efforts which have been made, particularly on the Continent of Europe and in America, to place the shoe or skate on the running rail or track mechanically when required for braking purposes, and to remove it from the rail or track by mechanical means when braking does not require to be applied to a particular vehicle or cut. Incorporated with this mechanism there are in some instances automatic means of returning the shoe or skate to its normal starting point, after being released from under the wheel of a vehicle and from the track (e. g. by means of a cut-out in the rail). It is obvious, therefore, that if such mechanical means can be controlled from a distance the carrying by hand of skates is avoided, and one man can undertake what previously required a number of individuals, provided he is accommodated in an elevated position where he can have a general view of the movement of vehicles from the hump, the extent of occupation of the sidings, and can pre-judge the amount of braking required (if any) in each particular instance. The actual apparatus may be purely mechanical, or worked hydraulically, pneumatically or electrically, but in most instances some form of electrical control is incorporated.

Another aspect of the shoe or slipper method, capable of being controlled, when necessary, from a distance, is a device incorporating automatic working, governed by the speed and weight of the vehicles themselves; but this appears to be in the experimental stage.

Turning now to (3) rail brakes, of which there are various types, the principle is distant control with the consequent concentration in one or more individuals of braking effort hitherto requiring a larger number of staff. The devices are controlled or operated hydraulically, pneumatically, magnetically or electrically, or in part combination, and are worked by an operator in an elevated situation, as he must both by day and night have a bird's eye view of the yard, including an unobstructed vision of the movement of vehicles from the summit of the hump.

This brings us to the end of the known types under broad headings of braking apparatus, details of which are described by the several reporters.

Turning now to the various reports, in report No. 1 Mr. Ctibor Fiala states that in the countries he has embraced only two administrations possess rail brakes and five use slipper brakes and these only in isolated instances, so that, as no other special methods are in use, he finds it very difficult to draw general conclusions from so small a number of examples. Mr. Fiala points out that these two appliances are placed below the gravity hump on a down gradient, and that the distance between the apparatus and the marshalling sidings is reduced to the strict minimum permitted by constructional considerations, also that usually a single brake is used per group of tracks.

Bearing in mind the relatively small data on which his report is based, Mr. Fiala is inclined to the view that rail brakes give better results than slipper brakes, quoting his own wording: « They (rail brakes) work more exactly, they allow a better regulation of the speed of vehicles and thereby so much the better ensure that the vehicles are stopped in the desired length. The vehicles suffer little damage and accidents are eliminated. Slipper brakes are, however, much simpler and cheaper.

» By the use of these two brakes the shunting of vehicles is accelerated; working is more regular, the vehicles can be relied upon after being shunted off to travel the desired distance; there is consequently a reduction in working

expenses, and, indirectly, in staff expenses. »

In my own report (No. 2), I stressed the desirability that where hand braking continues to be the practice, the brake fittings should, as far as compatible with the character of the vehicles, be of uniform design, i. e. within countries or groups of countries where interchange of rolling stock takes place, the object being to facilitate working and thereby achieve a higher standard of efficiency in hump shunting operations.

Attention was also drawn to the fact that such equipment fixed to the vehicles (and which can be made use of in flat shunting and at any time also at any place other than hump yards where vehicles may stand on gradients and require securing from spontaneous movement) avoids the necessity for providing manually placed slippers or shoes except in certain circumstances as supplementary to other forms of brake power.

In the countries I had under review comparatively very little use is made, or is necessary of the simple shoe brake, and in none of those countries is there, as yet, any form of distant controlled slipper or shoe, except in the case of the United States, where such appliances or electrically operated skates are used to supplement rail brakes when necessary, and in certain instances to act as stops towards the end of sidings.

With regard to rail brakes, I reported that the only one installation in Great Britain, that of the « Frölich » type at the London & North Eastern Company's new yard at Whitemoor, was not then formally opened for traffic. Since writing that, however, the apparatus has been brought into use, and is understood to be working satisfactorily on the whole. Inasmuch however as this was a newly constructed yard it is difficult to make comparisons, and as it constitutes the first instance of the application of rail braking methods to British conditions, the time is hardly yet opportune. in view of the need for adaptation to circumstances dissimilar from those in other countries, to form definite conclusions.

In the United States much progress has been and continues to be made with the introduction of the rail brake and the conclusion reached was that this method is eminently suitable where large and heavy vehicles are in general use. In that country, by the end of 1928, about sixteen large yards had been equipped with rail brakes or car-retarders, and since then it is understood further yards have been or are being similarly equipped.

Unfortunately only two Administrations in that country possessing car retarders replied to the questionnaire, whilst apparently others making use of this form of apparatus do not appear to be members of the International Railway Congress Association, so that adequate comparisons of the experience gained and the resulting conclusions are not possible.

Since the first car-retarding apparatus was introduced in 1923, the types, which are described in more detail in my report, appear to have resolved themselves into two, which however are similar in appearance and effect, one being operated electrically throughout and the other electro-pneumatically. No data is available to form a conclusion as to which of these types is preferable, if there is really any choice between them.

The operation of the retarders is performed from one or more elevated towers, according to the number of appliances to be manipulated, and whereas originally there was a tendency for the number and locations of retarders to be multiplicated, more scientific designing of the layout of the point or switching area on the « balloon » principle with the points or switches at more or less equal radii from the hump, has resulted in it being possible to reduce the number of locations of retarders, which

is more economical and results in more efficient performance of the work.

Whilst alluding to the question of lay-out of the point or switching area I would again re-iterate the statement in my own report that the matter was referred to at the London Session in 1925 — vide article No. 15 of the final summary of reports on shunting yards which read as follows :

« 15. — The distance between the top of the hump and the set of points nearest to the head of the sidings should be as short as possible. The lay-out of the head of the sidings should be such that there is no great difference between the resistances offered by the different roads, that the distance between the points at the head of the group of sidings and the fouling points should be reduced to a minimum and, as far as possible, the same for all the roads.

» If necessary the head of the sidings can be given a sufficient incline to overcome resistances due to curves and reverse curves. »

The more relevant conclusions reached in my report were as quoted below : « Consideration should be given in the case of all gravity or hump shunting yards, whether existing or contemplated, where the number of vehicles dealt with is considerable, to the question of introducing modern car retarding or rail braking methods, in order to decide whether savings in personnel or increased efficiency in working justify the cost of introducing such methods.

« Electrically controlled rail braking methods appear desirable where the rolling stock is of generally high capacity, but sufficient experience has not been gained (in the countries covered in my report) to demonstrate whether the advantages of rail braking justify the cost of installation and maintenance where the vehicles are of comparatively small capacity and are all fitted with hand brakes. » (*N. B.* — It should be noted that in the countries embraced in my own report there was no instance of distant-operated shoe-brakes solely).

A more extensive use of distant operated shoe brakes exists in the countries reported upon by Messrs. Pellarin and Farenc, with whose report (No. 3) I will now deal.

Several systems of distant-operated braking are in force in France and these appear to resolve themselves into the following types, several yards being equipped with one type alone, and others with a combination of types :

1. Rail brakes, such as the A. C. E. C. (e. g. at Blainville, Est Railway) and the Trayvou (e. g. at Narbonne, Midi Railway), also the Dague [e. g. at Longueau (Nord Railway)], each having special characteristics.
2. Slipper brakes (Midi type) — the normal or resting position of which is at the higher or commencing end of braking area such as at Bordeaux (St. Jean).
3. Slipper brakes (Deloison type — the normal or resting position of which is at the lower or terminating end of the area braked — such as at Lille (La Délivrance).

In addition to the above it is interesting to note that an automatic speed reducer is being experimented with by the Est Railway, built up of a number of elements arranged one after the other, each element consisting of a slipper moving along a slide and normally each slipper is at the beginning of its respective element. Respective slippers only come into use if a wagon is moving too quickly and needs braking.

Messrs. Pellarin and Farenc point out that some of the rail brakes take their energy from water under pressure or compressed air and others from electricity and springs. They include rails acting on the inside face of tyres only

or on both sides. In some instances the force can be regulated at the will of the operator, and in some cases this is not so.

They incline to the view that rail brakes are more accurate in operation than slipper brakes and have other advantages, but point out the heavy initial cost of rail brakes as compared with slipper brakes.

General remarks in regard to braking methods.

There seems to be no doubt that distant-controlled braking methods are preferable to, and more economical than, hand and portable shoe braking methods and they provide a larger margin of safety to men and material. Conditions however vary to such an extent in the different countries that it is not practicable to reach any precise conclusion as to particular types of apparatus, etc., but I have endeavoured to summarise the subject in a general way at the end of this report.

2. — Methods of ensuring that the vehicles travel on to the lines in the various groups of sidings.

a) *Point operation, signalling, etc.*

It would seem to be a natural corollary to the centralisation of control of rail braking and shoe braking, that the control of point or switch operation should be centralised in the same cabin or tower and that they should be worked electrically.

The men operating the brakes and the points or switches require to have adequate information as to the number of the siding on to which each vehicle is to go, particulars of heavy and fragile loads, with any other details necessary, all the vehicles being given in sequence of shunting.

The principal means adopted in distant-controlled rail or shoe braking methods are : loud speakers, luminous indicators, or more generally cut-lists or switching lists, transmitted either by pneumatic tubes or electric teletype machines.

It is also essential that these men should have some information as to the extent of occupation of the various sorting sidings. Their location should be in such an elevated position as to enable them in daylight and clear weather to see such occupancy and at night floodlighting of an adequate character is a necessity. In some instances a method of track circuiting, covering at least the point or switching area is a most useful help to the operators by furnishing them with visible indication on a desk or diagram immediately in front of them as to whether vehicles are clear or foul of the point or switching area.

b) *Means of propulsion or haulage along the sidings.*

Whatever means of braking are employed it is not possible to ensure that all vehicles will come to a stand buffer to buffer so that they can be immediately coupled together and therefore it is necessary for them to be moved or « closed up ».

In countries where vehicles are all of comparatively high capacity, and very largely elsewhere, it is the practice to use ordinary rail locomotives for this purpose which inevitably has the disadvantage of interfering with the progress of the ordinary shunting, at any rate in that particular group of sidings and during movement of such engines from one part of the yard to another.

To counteract this loss of output there is a practice of using various kinds of apparatus, e. g. capstans and road tractors.

The range of usefulness of capstans is limited and only in small goods yards are they an advantage over a rail engine and where the amount of work does not

justify the retention of a locomotive solely for that purpose.

The development of the internal combustion engine and the improvements in road tractors in recent years presents an economical proposition for the use of such machines in small goods yards for the movements of individual or small numbers of vehicles in place of horses, capstans or even locomotives, provided the track is made up to rail level.

Some administrations have found an economical use for such tractors in the larger marshalling yards but the governing consideration is sufficient space between the sidings or tracks and freedom from obstacles such as lamp posts, telegraph poles, etc. Unfortunately the sacrificing of valuable siding accommodation which the provision of the requisite space between tracks would necessitate for many administrations, such as in Great Britain, has prevented developments in this direction.

For intermittent light shunting or positioning of vehicles where they are not too heavy, the use of such petrol or paraffin driven rubber tyred road tractors presents interesting and economical possibilities, provided the tracks are made up to rail level with ballasting, old sleepering or timber at convenient points for crossing over tracks, even if the whole yard is not so constructed. The gradual growth of the average rail vehicle is rendering the use of horses for light shunting (as was formerly a common practice) an impossible if not undesirable task, and moreover such tractors can be used for street collection and delivery work by administrations undertaking this service.

SUMMARY OF CONCLUSIONS.

1. The methods employed in marshalling yards to control the speed of vehicles being shunted consist of :

a) Braking appliances fixed to the vehicle (hand brakes);

b) Portable shoes or slippers placed on the running rail or track by hand;

c) Shoes, slippers, or skates placed on the running rail or track by mechanical (including electrical) means, such placing being controlled from a distance;

d) Rail brakes or retarders parallel to the running rail or track exercising a lateral braking effect on the sides of the wheels of vehicles, such braking being controlled from a distance.

2. Hand brakes (*a*) and portable shoes (*b*) necessitate the personal attendance or accompaniment of personnel for the purpose of applying braking when necessary and to the desired extent.

3. Distant operated shoes or skates (*c*) and rail brakes (*d*) permit of completely or partially centralised control of braking requirements, and enable some reduction in braking personnel to be effected.

4. In hand and portable shoe braking, the personal contact and individual attention result in the braking responsibility being divided between a number of individuals.

5. In distant shoe or rail braking the responsibility is highly concentrated in one or a very few individuals who require to be located in an elevated position commanding a bird's-eye view of the sphere of operations.

6. At all large yards, where hump or gradient shunting is in operation or when new yards are contemplated, consideration should be given to the question of conversion to, or the introduction of, distant-controlled shoe braking or rail braking methods.

7. The difference in conditions, capacity and weight of vehicles in general, in the different countries, combined with the fact that distant-controlled shoe or rail brakes are largely in their infancy,

and are in the process of development and improvement and the lack of experience of them in certain countries, prevent any general conclusion being reached in favour of a particular type.

8. The initial cost of introduction or conversion to complete distant-controlled shoe or rail braking is high in comparison with methods employed hitherto, but savings varying in extent in different countries, according to former practices, by the reduction of personnel, can be effected, of a permanent and continued character.

9. The economies can be supplemented by the assembling (where not already done) of the control of point or switch operation in the same location as the shoe or rail brake control. It is also desirable that the points should be « quick-acting » and it is advantageous at high capacity hump shunting yards for the first sets of points below the hump to be capable of being pre-set electrically and automatically changed by the vehicles themselves.

10. The primary considerations in regard to the gradient for distant-controlled shoe or rail-braking are that it shall be such that the worst running vehicle under the most adverse conditions, curvature of track, weather, etc., shall reach the greatest distance required. Also that the preliminary character of the gradient shall be such as to give a sufficiently speedy impetus to vehicles or cuts at the start, so that they are sufficiently separated prior to reaching the points or switches and shall not stop in the point or switching area.

11. The braking pressure needed to absorb the surplus speed when necessary is either highly concentrated as in rail brakes, or if less concentrated, as in shoe-brakes, more, i. e., a succession of, appliances are needed. Space, therefore, in relation to the general layout, becomes a consideration to be taken into account.

12. The shoe brake acts on one wheel of a vehicle only, i. e., the leading wheel which mounts the shoe — hence a succession of appliances is generally required for this type.

13. The rail brake exerts lateral braking on the sides of all the wheels. Comparatively fewer appliances are therefore required. The length of the brake rails and the number are governed by the character and weight of the rolling stock in the particular country.

14. In shoe brake installations, the first set is usually placed at the foot of, or immediately below the first or steepest part of the gradient with as many more sets as many be necessary, on the leads into the groups of sorting sidings, with a further set at the commencement of each of the individual sidings clear of the point or switching area.

15. In purely rail braking installations the brake rails, one set or more as necessary, are usually located in the leads to the various groups of sidings only.

16. The greater the extent to which braking power, with the necessary elasticity of application, can be concentrated in the fewest appliances, the less staff of operators is required, so that the work can be speeded up, as an operator instead of having to watch a vehicle or cut through a succession of brakes, can the sooner turn his attention to the next oncoming vehicle or cut.

17. Certain forms of rail brake make it possible to obtain a braking force proportional to the weight of the vehicle or cut, which is an advantage, provided the construction is such that light vehicles are not lifted out when pressure is applied.

18. The initial cost of such rail braking appliances is comparatively high and necessitates certain standard features of design of layout of track, i. e. the balloon-shaped formation, with points or switches at more or less equal radii from the hump.

19. The initial cost of shoe braking

apparatus is stated to be appreciably less and in suitable instances may be applied to existing layouts.

20. Certain types of rail brake are of such length that brake pressure can be increased or decreased at will as vehicles or cuts of vehicles are passing through them.

21. With the shoe brake there is not the same facility, as once the wheel has mounted the shoe the pressure is constant until the shoe leaves the track at what is a fixed position or cut-out.

22. One form of shoe brake has its normal rest position at the lower end of the brake area and is propelled towards an oncoming vehicle to the pre-judged distance necessary by the operator at will.

23. Another form of shoe brake has its normal rest position at the higher or commencing end of the braking area and may be placed on the rail at will by the operator as necessary and provides for the return of the shoe to the starting point automatically.

24. Rail brakes may be operated electrically, hydraulically, pneumatically, or magnetically, or in part combination, and control of the apparatus is effected electrically.

25. A purely automatic shoe braking appliance governed by the speed and weight of vehicles approaching and by the extent of occupation of the siding to be entered is in the experimental stage but this as yet appears to necessitate every wagon being shunted separately.

26. In all forms of distant controlled shoe braking and rail braking, it is desirable for the operator to be furnished with a « cut list » giving a list of the vehicles, the siding for which each is destined, whether loaded or empty, or containing fragile goods or otherwise and other special features (if any).

27. Flood lighting of modern type is desirable for all large marshalling yards and particularly where rail braking or shoe braking methods are in force.

28. Colour light signalling providing suitable code is advantageous for controlling speed of hump operations, being duplicated as necessary and supplemented by oral code signals such as electric or klaxon horns if required.

29. Pneumatic tubes for the transmission of cut lists or other documents afford a desirable means of expediting the conveyance of train papers, cut lists, etc., between the essential posts in the yard.

30. Electric teletype machines afford a ready and expeditious means of transmitting at one operation the switching or cut lists and of giving instructions to the rail brake and point or switch operators' cabin and other parts of the yard as necessary.

31. Loud speaker telephones for verbal messages are of considerable benefit for rapid communication between certain key positions in a hump yard.

32 In general, the advantages claimed for distant-controlled braking methods embrace some, if not all, of the following advantages, according to local circumstances, and the particular type of apparatus used :

a) Reduction in number and cost of brakesmen;

b) Damage to goods and rolling stock diminished, with consequent reduction in claims and maintenance costs;

c) Increased safety of employees;

d) Slow working due to adverse weather conditions is counteracted;

e) Operating capacity of yards is enlarged;

f) Closing of small yards by concentrating the work at one large yard;

g) Certain yards closed during part of the 24 hours;

h) Reduction in locomotive-hours;

i) Avoidance of employment of extra staff in bad weather.

33. In certain instances where space permits, economical use has been made of small road tractors capable of running between the different sidings and crossing the rails when necessary, for the purpose of propelling or hauling one or more rail vehicles at a time and closing up vehicles on shunting sidings.

SUPPLEMENT.

Since submitting the special report, a report by Dr.-Ing. Gottschalk, dealing with the Deutsche Reichsbahn Gesellschaft (German State Railway Company), has been received) [1].

This report is very informative and instructive and reveals the interest displayed by the Reichsbahn in the direction of encouraging the development of more scientific and economical methods of performing hump shunting. Various inventions are apparently being tried at different places, although certain types have been in use for some years past.

One method of rail-braking of a unique character (and the only instance of the kind mentioned in any of the reports) is an electromagnetic rail brake in use at Magdeburg-Buckau. Full details are given in Dr. Gottschalk's report, but briefly the metal wheels of a vehicle passing through the brake rails or plates, which are connected with electro-magnets, cause eddy currents. The braking, therefore, consists of an eddy current braking effort and a friction braking effort. Of this it is stated that two-thirds belong to the eddy current effect and one-third to friction, so that the brake rails suffer little wear.

Another interesting device in the experimental stage is an accelerator for giving added impetus to bad running vehicles, and during unfavourable weather conditions, but a final opinion cannot yet be expressed in regard to this. Of special interest are the methods adopted at a number of German yards for providing screening from prevailing winds.

A number of the conclusions reached by Dr. Gottschalk have, in the main, already beem touched upon. Attention is, however, drawn to the desirability at high capacity hump shunting yards of the first sets of points below the hump being capable of being pre-set electrically, and automatically changed by the vehicles themselves.

(1) See *Bulletin of the Railway Congress*, January 1930, p. 309.

QUESTION XI.

(SIGNALLING OF LINES FOR FAST TRAFFIC AND IN MAIN STATIONS. DAYLIGHT SIGNALS. AUTOMATIC BLOCK SYSTEM),

By W. STÄCKEL,
Special Reporter.

INTRODUCTION.

An extremely valuable survey of the existing signalling systems employed on railways was given at the last Congress, in 1925, in the reports of Messrs. W. J. Thorrowgood, W. H. Elliot, Laigle and C. de Benedetti, and in a special report prepared by the last named. The subject of this year's report is the detailed consideration of certain special signalling matters, with the latest information relating to daylight signals and automatic block working. As the signalling systems in Denmark, Norway, Sweden and Germany could not be dealt with at the last Congress, these also are the subject of review.

The following report is based on :

1. Report by Mr. G. H. Dryden, Signal Engineer of the Baltimore & Ohio Railroad Company, for America, the British Empire, China and Japan.

2. Report by Mr. P. Kristensen, Signal Engineer of the Danish State Railways (all countries except America, the British Empire, China, Japan, Belgium, France, Germany, Italy, Portugal, Spain and their colonies) (3).

3. Report by Mr. G. C. A. Willaert, Principal Engineer, Belgian National Railway Company, on France and Belgium (4).

4. Our report on Germany (5).

Those questions which appear most important have been selected from these reports, and in discussing each of them the principles and proposals contained in the separate reports have been collated.

I. — Signalling equipment of express lines and at large stations.

1. — General considerations

At the London Congress, interest centred primarily on the question as to how many signal indications are absolutely essential in operating express lines with mixed traffic. Nevertheless, no final conclusions on this point were arrived at. Mr. Kristensen gives in his report a general criterion which is of importance for judging this question. He demonstrates that the number of signal indications necessary depends upon the nature of the block system.

Whilst the Central European railways, like the British railways, are operated almost entirely on the full block system, in North America, for example, and on a

(1) Translated from the German.

(2) See *Bulletin of the Railway Congress*, September 1929 number, p. 1805.

(3) See *Bulletin of the Railway Congress*, December 1929 number, p. 3155.

(4) See *Bulletin of the Railway Congress*, February 1930 number, p. 723.

(5) See *Bulletin of the Railway Congress*, March 1930 number, p. 997.

part of the French lines, a permissive block system is in use. Since this system necessitates a signal aspect for a part of the signal which represents a conditional stopping indication, and as in addition signals with an absolute stopping power are indispensable, as for protecting stations and junctions, it follows that the signalling is not so simple as on the absolute block system. On a portion of the French railways the semaphore type is used for permissive block signals, whilst rectangular discs are employed for signals with absolute stopping power. In North America when the stopping signal permits running on after stopping (« stop and proceed ») it is distinguished from the absolute stop signal by the addition of a number plate or marker light, a pointed end to the signal arm, or by a combination of these.

According to Mr. Dryden's report, further requirements have arisen in North America in recent times with regard to the number of signal aspects required, which are connected with the special nature of the traffic conditions, notably the great train weights in freight working. Whereas in Europe heavy goods trains are generally considered to be between 1 000 and 2 000 tons, in North America trains of 7 000 to 10 000 tons are hauled, with 110 to 130-ton wagons. With train weights of this order, starting on gradients presents serious difficulties. Hence, it has been necessary to add to the signal indications the so-called « grade » signal, which permits a fully loaded goods train to enter an occupied block section without stopping, provided the speed does not exceed 24 km. (14.9 miles) per hour; passenger trains must stop first before proceeding. This method is made use of also in China and Japan.

The further considerations by which the number of signal indications may be influenced are revealed in the following discussion of the individual items of signalling practice.

2. — Protection of danger points and block sections.

In the early days of signalling many railways protected danger points by signals which were placed at such a distance from the danger point as corresponded to the maximum braking distance. Such a signal, when in the stop position, indicates to the driver that he must bring his train to a standssill before reaching the danger point.

Signals of that kind, which are still used on some French lines in the form of circular red discs, may thus be overrun when in the stop position. Later, most railways adopted two signals for protecting danger points, a main or home signal near to the spot, and a cautionary or advance signal at some distance from it, which give warning of the position of the home signal. A train can always run past the advance signal, but must stop before reaching the home signal if it is in the stop position. Where the absolute block system is in use, the same signals and signal aspects are used also for protecting block sections.

On lines which have very short block sections, the interposition of advance signals between the home signals leads to an undesirable multiplication of signals. There are two methods of avoiding this. Either the advance signal can be situated at the same point or on the same support as the home signal so as to give a combined signal, or the indication of the home signal can be extended by an additional aspect so as to show the position of the next signal ahead. The latter arrangement — the « disguised advance signal » — is used most extensively in North America. An arm on the home signal indicates « road clear but be ready to stop at the next signal » when pointing upwards at an angle, but when pointing vertically upwards gives a clear road without qualification. This arrangement is made use of also in Argentine.

Outside America, the three-position type of home signal in which the distant signal is incorporated, is found chiefly on railways using light signals. Mr. Dryden cites in his report examples in Australia, Africa, China and Japon; the German report describes a similar arrangement on the Stadtbahn (Metropolitan) in Berlin.

The prevailing practice in Europe is, however. as stated in the reports of Messrs. Kristensen and Willaert, to give advance signal indications by means of an *independent* advance signal or by a *special indication* on the home signal in the rear.

3. — Distance of home signal from danger point.

The reports of Messrs. Kristensen and Willaert give some instructive data on this question. Generally speaking the minimum distance prescribed varies between 50 and 150 m. (164 and 492 feet) on the French and Belgian lines, and between 50 and 300 m. (164 and 984 feet) on the railways of Central Europe. Such distances are not usually prescribed for the starting signals at stations. In our opinion the protective interval is for the purpose of meeting *small* irregularities in the functioning of the brakes or in their application. There is no suitable theoretical basis for evaluating what is an adequate figure for such a purpose. Errors such as failure to notice a signal or complete failure of the brakes, cannot be rendered innocuous by *short* protective intervals. It is well-known that in Great Britain the protection of the danger point is amplified by a caution at the home signal in the rear, and if this is at « danger » the train must first be brought to a standstill before it proceeds to the actual covering signal. The interesting questions of the adequacy of this method and the extent to which it is used, are not dealt with in the reports.

4. — Distance between advance signal and home signal.

The reports of Messrs. Kristensen and Willaert collate information which shows that the spacing of advance signals is usually determined by the maximum braking distance. This spacing is varied on most lines according to the track gradient and the maximum speed of the trains. Mr. Kristensen points out that the result of this principle is that only trains working with the *maximum* braking distance can use the advance signal as an indication of the point at which they must apply the brakes. Therefore, he is in favour of the adoption of a fixed advance signal interval, such as is in use in Denmark (400 m. = 1 312 feet) and in Holland (500 m.=1 640 feet).

The idea of using the advance signal as an indication to the driver of the interval to the home signal has been given up in Germany recently, and it is permissible to increase the interval from the usual 700 m. (2 296 feet) to 1 500 m. (4 920 feet) in cases where it is possible and desirable by this means to combine the advance signal with the next home signal in the rear.

Cases which give rise to special difficulties are those where the block sections are shorter than the maximum braking distance. Such cases occur in North America and probably have to do with the fact that unusually long braking distances are necessary there of from 1 200 to 1 500 m. (3 936 to 4 920 feet). In these circumstances it is necessary for each block signal to show, when in the starting position, the condition of the next two block signals ahead, and this calls for four-aspect signals. It is well-known that in England also it has been found necessary to adopt such an arrangement on very busy lines with mixed traffic; the problem is solved there with the aid of light signals using red, single orange, double orange and green aspects.

5. — The form of home and advance signals.

The semaphore type has persisted almost generally for home signals. The exceptions on the French lines have already been mentioned under point 1. The position is different in the case of advance signals. Mr. Kristensen distinguishes in his report between the *English* system and the *Central European* system. Whereas the semaphore type is employed for advance signals in English practice to which Belgium, Denmark, Italy and Holland also adhere, the Central European system gives preference to a round or square banner as a cautionary sign, *i. e.*, for indicating by the advance signal when the home signal is in the stop position.

The German report outlines the advantages which we consider this system possesses. We attach value to arranging the advance signal as nearly as possible on a level with the driver's eye, so that when running past it, he is to some extent compelled to notice it. At this height it is frequently impossible to employ a semaphore of sufficient length owing to limitations of space. The visibility of a semaphore arm depends very much on the background, for which reason they are often placed at a considerable height; on the other hand, we have found that the banner is much less affected by the background, and that it can, therefore, be placed lower.

If the home signal shows « clear », the advance signal is usually turned to the edge-wise position, which does not give a position aspect. Most railways which employ this type, therefore, fit at the foot of the advance signal a *recognition sign* in the form of a cross, and this greatly simplifies picking up the edge-wise disc, and practically eliminates the disadvantage attending the absence of a positive aspect.

In the past few years several European railways have adopted warning boards or posts as a preparatory indication on advance signals. In order to render the signalling system uniform, it is the practice in Belgium, Denmark, Germany and Holland on express lines to fit warning boards or posts in advance of *all* the advance signals of home and block signals and of the protecting signals for junctions. Other railways restrict their use to *special* cases.

When night signalling is considered, the variations in practice are still found to be considerable. On one group of railways a white light is still used on main and distant signals to indicate « clear ». Recognising the disadvantages of this type of signal, the majority of lines employ for important signals only the three colours, green, orange and red, *green* being used always for the home signal indication of « clear » when no qualification is imposed, and *red* for « stop ». Yellow or orange is becoming more and more standardised as the cautionary aspect of the advance signal. Generally speaking the « clear » indication is then given by green, but on railways which use a white light, green gives the cautionary signal and white the « clear ».

Mr. Kristensen refers in his report to the difficulty which arises in night signalling by reason of the fewness of suitable signal colours, and points out that this can be overcome by using a winking light for a part of the signal indications, as is done in Denmark, Norway and Sweden.

He comments on the fact that many railways use such lights solely for reasons of economy, instead of using them for distinguishing various signal indications. Indication by means of a winking light is only practicable, however, for railways which no longer use oil lamps for the signals in question.

6. — Special features of arrival signals.

Individual railways attach varying degrees of importance to the question of

whether a distinction should be made at all, and if so the method to be adopted, for differentiating between home signals for a deviating track and a straight-through track. This matter has been discussed in detail in the reports of Messrs. Kristensen and Willaert and in the German report. In Denmark it has not been the practice hitherto to give such an indication of the route on the home signal; but according to the information given by Mr. Kristensen, a commission is now considering the matter and it is contemplated that provision shall be made for apprising the train of the route by means of a clearly visible deviation signal where the points are situated.

There are two different systems in use on those railways which give an indication of the route on the home signal, namely, the geographical system and the speed system. In the geographical system the engine driver is informed which route the train will take; he must then control the speed in accordance with his knowledge of the line. In the speed system no exact information is given concerning the route, and the only indication given is the maximum speed at which the train may approach the home signal. In this case it may be possible for the same signal to be shown both for the through road and the branch road, that is to say, when a considerable reduction of speed is necessary for *all* roads.

Most railways make use of the geographical system. In this case there are two alternative arrangements, the vertical and the horizontal. In the former, the signal arms or lights for the various routes are placed one above the other, and in the horizontal or bracket system the single-arm masts for the different routes are arranged side by side on a bracket or a gantry.

The bracket system has spread from Great Britain to Belgium, Holland and Italy, whilst the French and Central European railways use the vertical system. In France the route indication is usually effected by a special indicator at the first deviation point.

Recently most railways using the vertical system have limited the number of signal indications to two, *i. e.*, two semaphores or at night two lights, an inclined semaphore or green light indicating the through road, whilst for all deviating roads the same signal of two inclined arms or two green lights is used. In Norway this procedure has been reversed for the reason that if one light should then become extinguished, the signal shown is always the one which calls for the greater degree of caution.

In North America the speed principle is made the basis of the forms given to the signal indications. Double-arm signals are also used there for home signals. The multiple-arm route indicators for the geographical system on the French railways gives an indication of the speed *at night* as well as by day, a white light indicating full-speed, and a green light a reduced speed. At the present time Germany is on the point of going over from the geographical to the speed principle. The single-arm signal will in future mean « proceed freely », the two-arm signal « proceed with reduced speed through the zone of points ». The reason for this is that the locomotive staff in Germany has to be acquainted with the tracks at large centres in an extensive area of lines and travel over some roads comparatively seldom. Hence, the information given by the signals must be made to depend as little as possible upon exact knowledge of any locality. The speed principle is more suited to this purpose than the direction principle. Only when special considerations require it, is a separate indication given of the road which has to be traversed slowly, by means of a special signal not designed for visibility at a distance, *e. g.*, a route indicator with numbers.

The principles underlying this arran-

gement are as follows. It is necessary for the engine driver to recognise from a considerable distance only whether he can maintain his speed, or whether he must reduce it, or stop. He needs further information concerning the track on which he is to run in, only when he has arrived in the neighbourhood of the home signal, because any appropriate action he may have to take, *e. g.*, stopping at an outer platform, has only to be taken in front of the home signal. This applies also to information concerning the indication of the starting signal which has yet to be discussed.

Irrespective of which system is chosen for the formation of the home signals, the question has to be decided as to what signal aspect is to be shown on the advance signal when a branch track has to be entered at a reduced speed. On some railways the cautionary position is shown by the advance signal in this case, that is to say, the same signal indication is given as when the home signal is at « stop ». But this means that the advance signal loses its original purpose for trains which habitually traverse the junction. It gives them no clue at all as to the position of the home signal. For this reason the German railways, *e. g.*, exhibit the « clear » position on the advance signal, even when a branch line is to be taken. Experience of accidents has shown, however, that this is likely to be dangerous in the case of unusual diversions of the trains.

Considerations of this kind explain why the movement to provide advance signals with three aspects continues to gain favour. Advance signals of this kind are in use in Belgium, Holland, Sweden, and on the lines in Alsace-Lorraine. As an alternative, the French Nord Railway makes use of a special « proceed slowly » signal, and the Est Railway a transparent sign with indications of the speed. Preparations are being made for the introduction of the three-aspect advance signal in Germany. Further, in North America the signal system provides for cautioning the engine driver at the home signal in the rear when he has to proceed slowly.

7. — Special features of starting signals.

The arrangement that is most extensively adopted for starting signals is to place a separate starting signal close to each departure track before the point is reached at which the tracks run together. And for this purpose most railways make use of the same forms as for home and block section signals. Contrary to the practice in respect of home and block signals, a number of railways do not favour the provision of advance signals to give indication of the starting signals. Where an advance starting signal is used, it is nearly always situated next to or immediately in front of the home signal. In Denmark and Great Britain a second arm underneath the home signal is used as an advance signal for the starting signal. At a number of stations in Denmark the starting signals have been *given up*. In this case the second arm on the home signal shows whether the train may run through the station or must stop in it. In North America the departure signal is embodied in the arrival signal in a disguised form, and as in the case of block signals (see section 1) the position of the next signal is announced by a special signal aspect.

8. — Shunting signals.

Alongside the signalling equipment for working the trains at large stations, an important part is played also by the signals for shunting operations. Mr. Kristensen has dealt with this subject fully by reviewing the practice in shunting signalling in Central Europe. The German report draws attention to an essential difference which exists between the signalling of two groups of railways. One of these groups, consisting chiefly

of the Central European railways, does not employ interlocks for ensuring the safety of the shunting roads. Shunting is carried out with hand signals and by the station staff using sound signals. The running of the trains is protected against shunting movements by the use of safety switches, catch points, derailing devices, or track locks.

The other group which includes Great Britain, France and North America, carry out shunting operations in a similar way to train working, using signals and safety interlocks between the points and the signals; sometimes the train signals are made use of, and in other cases special shunting signals usually of the dwarf type are employed. In Sweden the transition has been made from the first to the second group in some of the new safety equipments. A closer examination of this phase of signalling would afford suitable material for a subsequent Congress.

9. — Signal operating equipment.

In connection with this subject Mr. Willaert has considered how far progress has been made towards controlling the safety appliances of large stations from a single centralised box utilising power actuation. He mentions such a centralised arrangement of the Mors system at Laon station on the French Nord Railway, where the farthest points are 750 m. (2 460 feet) from the operating cabin. He also refers to two similar installations on the French Midi lines, as well as some central equipments in Belgium. In these systems points which are out of sight of the operating cabin are only connected to the latter if they are not to be used for shunting purposes.

Mr. Dryden gives a detailed account of the progress made in North America with centralisation. In recent times the control of points from cabins situated at a considerable distance have come very much into favour. Two central installations in particular have created much interest, one of which covers 64 km. (40 miles) and the other 32 km. (20 miles). In both cases the whole of the safety appliances of the district are controlled from a single dispatcher position. At the same time the dispatcher has at his service an automatic indicator which keeps him informed as to the running of the trains through the various sections of the routes. The requisite power for moving the points at the different stations is provided by local storage batteries working at 20 volts. The points operate slowly, 5 to 13 seconds being required for one movement, and their movements are « supervised » by control currents from the dispatcher installation. Steps are being taken to put into service further equipments of this kind. Considerable use is also being made in North America of automatic return points for remote positions.

II. — Daylight signals.

Mr. Dryden reports that daylight signals have already been installed on express routes in North America comprising an aggregate length of 21 187 km. (13 165 miles).

Three systems have become established, *viz :*

1. Colour light signals : 16 867 km. (10 481 miles).
2. Position light signals : 3 423 km. (2 227 miles).
3. Colour position light signals : 735 km. (457 miles).

Searchlight signals form a special type. Whereas in the ordinary coloured light signal the change of colour is effected by providing a separate lamp for each colour and switching into circuit whichever lamp is required, with the searchlight only one lamp is fitted. A moveable frame carries glasses of the various colours and is moved in front of the light by means of an electromagnet,

Although the use of daylight signals has spread from North America throughout the whole world, the extent to which they are used on other railways is still quite small. In Europe they have been adopted by Great Britain, Norway, Sweden, some French railways, and in a minor degree by Denmark, Germany, Finland and Holland. The German report makes reference to experiments on a stretch of track with particularly severe bends and visibility conditions, and comes to the conclusion that on sharp bends it is necessary to use special lenses with a side dispersion up to 16° total beam angle, and that it is inadvisable to economise too much in the current consumption of the lamps.

In all reports, the opinions expressed concerning the practical success of daylight signalling are so favourable, that its more extensive adoption is undoubted.

III. — Automatic track circuit working.

As in the case of daylight signalling, so also with track circuits — North America is far in advance of other countries. Of the passenger-carrying networks in the United States extending to 320 000 km. (200 000 miles), some 93 000 km. (58 000 miles) of lines are equipped with track circuit working, as against 95 000 (59 000 miles) worked on the manual block system. In Europe, on the other hand, only comparatively small stretches on some lines are provided with automatic block apparatus. Mr. Willaert deals at length with installations of this description in France, particularly with those on the French State Lines, the Midi and the Est Railways. Mr. Kristensen describes experimental equipments in Denmark, Finland, Holland and Sweden. The German report refers to a new installation on the Metropolitan Railway in Berlin.

Mr. Dryden draws special attention to the use of the automatic block system on single-line routes in North America. As regards other countries, he makes particular reference to New Zealand and Japan. In the last-mentioned country over 888 km. (552 miles) of single-line track have automatic track circuiting on the American system. He gives as reasons for the extensive adoption of this system in North America the lengthy sections on the trans-continental routes and the high wages paid. Mr. Willaert puts forward the view that even with dense traffic the automatic system is not economical if the stations are close together, and consequently the economy in staff is limited. In the German report attention is directed to two circumstances which militate against the more extensive adoption of automatic block working in Germany. The first is the difficulty of construction on lines carried on steel sleepers. The second is the reluctance of some railways to introduce permissive block working, such as is generally necessary with automatic equipments, owing to their staff not having been schooled to permissive running by long usage.

Otherwise the experience with various systems is favourable. They give the impression of increased safety because of the elimination of the human-error factor present in manual block working. The cases where a wrong signal indication has occurred on the automatic systems in use, have been extraordinarily few. On the French Midi Railway, for example, the proportion of faults was one in ten millions. In order to eliminate the risk arising from a faulty signal remaining in the « clear » position after the train has entered the section, most European installations incorporate an interlock which ensures that on the occurence of such a failure the preceding block signal cannot give the « clear » indication. This renders quite certain that the train is always protected by a « stop » indication.

It seems advisable in cold climates to combine with automatic block working

the use of daylight signals, with a view to avoiding moving parts which might be affected by low temperatures; this is of importance in the case of signals which are not under continuous observation.

IV. — Conclusions.

As the present report forms a continuation of the work of the previous Congress, it is important to link up our conclusions with the resolutions arrived at by that Congress and to see how far the later results modify or expand the earlier opinions.

The *first* resolution affirmed that one group of railways found *two* signal aspects sufficient on *home signals* and *two* signal aspects on *distant signals,* whilst other lines declared that three or even four signal aspects were necessary.

The matter now before us enables this point to be supplemented on the following lines :

As the basis for signalling express train routes a *home signal* with *two* aspects and an *advance signal* also with *two* aspects are necessary. The advance signal can also be *replaced* by the addition of a *third* aspect to the home signal. Where the length of a block section is less than the maximum braking distance required, home signals with four aspects are recommended, with the omission of the advance signal.

« An extension of this signalling by additional signal aspects or signal elements may be necessary for the following purposes :

A. *Home signal :*

1. To permit the permissive passing of « stop » signals after a preliminary stop.

2. To permit heavy goods trains to run slowly past the « stop » signal on gradients.

3. To specify speed limits through the section, or on approaching the next home signal.

40. To specify a speed limit through points adjacent to the home signal (when branching off), or alternatively.

5. To indicate the route (at turnouts).

B. *Advance signal.*

As a caution in respect of a signal indication according to A4 or A5 on a home signal (three-aspect advance signal).

However much it may be desirable to restrict as much as possible the number of signal indications, little advice in this direction can be given without putting obstacles in the way of that increased simplification of working which can be attained by using a greater number of signal aspects ».

The *second* resolution related to the use of three semaphore positions for giving three signal aspects. The following extension is recommended :

« For advance signals, which should be on a level with the engine driver's eye, a disc may be used as a cautionary « stop » signal. »

The *third* resolution deals with the three colours to be used for lights corresponding to the three semaphore positions. The following supplement is suggested :

« Any further signal aspects that are necessary can be obtained by grouping these lights in pairs or banks, which may be vertical, horizontal or diagonal, or by the addition of a marker light, or by a searchlight arrangement. Care must be taken that the extinction of one light does not result in a more favourable signal indication. »

The *fourth* resolution concerning warning boards or posts and similar cautionary signs, and the *fifth* which expressed approval of electric lighting of signals, do not call for any extension.

The sixth resolution recommending investigations of daylight (luminous) signalling could be amplified as follows :

« *Daylight signals* have the advantage over position signals (semaphore-disc) that their visibility is not affected by an unfavourable background, by mists or by twilight. They avoid moving parts which may be affected by frost.

« Special attention must be directed to a good beam angle on curves and to good visibility for trains passing close to the signal; also to a reliable supply of electric current. »

The seventh resolution recommended investigations with automatic block signalling in conjunction with daylight signalling. It might be amplified as follows :

« *Automatic block working* with suitable lay-out and methods of installation gives a better safeguard against incorrect signalling than manual block working.

Considerable economy can be obtained with the automatic system on lines where the stations and block signals are far apart, but not when they are close together. Further, the automatic block system should be restricted to lines constructed with wooden sleepers and, when these carry dense traffic, it should be installed only when there is no objection to the permissive passage of a train into an occupied block section. »

In view of the widely varying opinions expressed in the several reports concerning the distance of the home signals from the danger point, and the advance signal interval, no recommendation can be put forward for a resolution on these matters. On the other hand, the following conclusion might be recorded concerning the more extensive adoption of centralised operation :

« The use of power operation has rendered possible the control of extensive station installations from a *single* control frame. Such centralisation is particularly expedient when the outlying points are not used for shunting.

The control of the whole of the safety appliances of a long stretch of line from a single dispatcher point has proved to be practicable, low-voltage batteries being installed locally for operating the points by means of slow-running motors. It is desirable to continue investigations on this subject. »

On the question of signalling shunting operations, the resolution was as follows :

« The methods adopted for ensuring the safety of shunting movements at large stations are on some railways similar to those used to safeguard the running of trains; on another group of railways, however, these safeguards are dispensed with and they are satisfied to protect the traffic against shunting by safety switches, train locks or mechanical blocks or derailers.

It is desirable that further consideration should be given to this question, also to the advisability of making use of main signals for ensuring the safety of shunting traffic. »

Mr. C. de Benedetti, the reporter at the last Congress expressed the opinion that it might be possible to standardise signalling, at any rate for express train routes. The present reports give little hope of the early fulfilment of this ideal, owing to the fundamental differences that exist.

The task of standardisation could be carried out most easily if the whole of the existing signals could be scrapped at one time and replaced by such new system as may be devised. A process of this kind might in certain circumstances be adopted by a railway of limited size, but on a large and complicated network a revolutionary change of this character would be impossible, not only for operating reasons, but also on account of economic considerations. Ra-

ther is a gradual development necessary with due attention to the following guiding principles :

a) The indication, which an existing signal aspect conveys, should be altered only if the change can be effected throughout the whole network at one and the same time; it follows that such an alteration is possible only in cases where the necessary technical modifications are not too extensive.

b) If the signal aspect for a given indication is superseded by another one, care must be taken that during the transition period the old aspect can be used *alongside* the new one. But the continued existence of both aspects for the same indication should be avoided.

c) New signal indications must be expressed by *new* signal aspects, in cases other than those specified under *a*), where the meaning of an existing aspect is changed.

This summary of the principles to be observed shows how intimately the future treatment of this question is bound up with what has been done in the past. The difficulties which arise from this cause preclude the adoption by the individual administrations of large systems of many changes which would otherwise be desirable, and form an obstacle to the immediate and general introduction of uniformity in the principal signals used in various countries.

In spite of this rather unfavourable outlook for the future, it may be emphasised that the comparative study of the various practices in signalling, which the reports so far made have afforded, is extraordinarily valuable and will undoubtedly have the effect of inducing the railways to guide the future development of their signalling as far as possible in accordance with the ideas that have been contributed to a common pool.

SUPPLEMENT.

After having compiled this special report, the report of Messrs. Antonio Gibert, Chief Electrical Engineer of the Madrid-Saragossa-Alicante Railway, and Julio Nogués, Assistant Chief Traffic Engineer of the same Railway (1), dealing with Spain, Italy Portugal and their colonies, came to hand.

The report in question gives an instructive comparison of the systems with independent advance signals and with advance signals replaced by three-aspect indication on the previous home signal. The report leads to the conclusion that *three-aspect signalling* would tend to produce operating delays on *long* block sections, owing to the caution for a stop signal being given too early, and that this system necessitates dividing the track into *short* block sections. Therefore, this system appears to be expedient only in the case of very dense traffic or in conjunction with automatic block working, in which cases the number of block sections can be increased without increasing the wages bill; the report recommends the use of independent advance signals where these conditions do not apply.

Attention may also be directed to the experience which the Madrid-Saragossa-Alicante Railway has accumulated in operating a stretch of double line 107 km. (66.5 miles) in length with automatic block working (alternating cur-

(1) See *Bulletin of the Railway Congress*, April 1930, p. 1161.

rent). By doing away with interlocking between the individual block signals and using three-position block relays for the three-aspect signals, a very simple scheme of connections has been achieved which has eliminated the necessity for special cable connections between the blocks. Further, the method of working with signals normally in the « line clear » position has been used on account of the simplification of connections which it permits.

Having regard to the conclusions contained in the report of Messrs. Gibert and Noguès, the following proposals are made for supplementing still further the 1925 resolutions :

To the first conclusion :

« The determination of the distance between advance and home signals should be based upon the most unfavourable conditions of braking and visibility. »

To the sixth conclusion :

« Daylight signals are particularly suitable for giving more than three signal indications on one signal, by the supplementary use of various groupings of pairs of coloured lights. A comprehensive signal of this kind which shows to the observer at any time only one definite signal aspect is preferable to the combination of several two or three-aspect conformation signals. »

To the seventh conclusion :

« The method of working with signals normally at « clear » offers advantages over the method with signals normally at « danger » for automatic block operation, especially if daylight signals are employed. »

[621 .132.8 & 656. 22]

QUESTION XII.

(ECONOMICAL TRACTION METHODS FOR USE IN PARTICULAR CASES) (1).

By O. A. GAEREMYNCK.

Special Reporter.

Question XII was dealt with in five reports drawn up respectively by Messrs :

R. H. NICHOLLS, for the British Empire, China and Japan (2);

H. HUNZIKER, for all countries excepting America, the British Empire, China, Japan, Belgium, France, Germany, Italy, Portugal, Spain and their Colonies (3);

O. A. GAEREMYNCK, for Belgium, France, Italy, Portugal, Spain and their Colonies (4);

LEIBBRAND, for Germany (5);

H. B. VOORHEES and Geo H. EMERSON, for America (6).

In German the question was formulated in more general terms than in English and French. The wording in the latter languages was such as to confine the reporters to an examination of traction methods. The German wording included in the first part of the question all the details of the organisation of train working and so, in his report, Mr. Leibbrand has considered certain aspects of the question not dealt with by the other reporters.

A. — Organisation of train services on the minor lines of the large systems, carrying little traffic and of little used trains on the more important lines of these systems.

Nothing of particular interest was reported as regards goods trains.

In the case of passenger trains, all the reporters mention the use of more or less light weight locomotives, and of rail motor coaches with internal combustion motors; the first three reporters state that steam rail coaches are used; Messrs. Nicholls and Leibbrand call attention to electric rail motor coaches with accumulators, and Mr. Hunziker notes that on electrified lines with overhead equipment electric motor vehicles are the only ones to be considered; he also mentions the use of Diesel locomotives, as do Messrs. Voorhees and Emerson.

Many of the railway companies moreover have under consideration trials of these different methods.

The cost of traction includes :

1. Driving costs (including braking);

2. Cost of motor stores, especially the cost of fuel and lubrication;

(1) Translated from the French.

(2) See *Bulletin of the Railway Congress*, September 1929 number, p. 1869.

(3) See *Bulletin of the Railway Congress*, December 1929 number, p. 2859.

(4) See *Bulletin of the Railway Congress*, January 1930 number, p. 147.

(5) See *Bulletin of the Railway Congress*, February 1930 number, p. 585.

(6) See *Bulletin of the Railway Congress*, March 1930 number, p. 771.

3. Terminal charges : turning, handling stores, cleaning fires, etc.;

4. Upkeep and repair expenses;

5. Financial expenses : interest on and amortization of rolling stock and fixed plant.

The first of these can be reduced to a minimum if the motor is handled by one man. The internal combustion motor and the electric motor are best adapted for single man operation; the steam motor however can be so adapted, and in Germany, France and Holland, in certain cases, steam locomotives are run by the driver alone, his task being lightened by fitting semi-automatic stoking; in addition the guard can also pass from the first coach to the foot-plate of the locomotive and this covers the lack of a stoker, especially when it is a case of stopping the train should anything happen to the driver. With the internal combustion or electric motor the « dead man's handle » arrangement is used. Conditions of work — hours and wages — are generally the same for both rail motor coach and locomotive drivers.

A reduction in the cost of fuel can be obtained first of all by reducing the dead weight hauled which naturally leads to the employment of the rail motor coach combining motor and carriage or wagon in a single vehicle, and secondly by improving the efficiency of the motor through the use of superheating and compounding with the steam engine; through the substitution of an internal combustion engine for the steam engine with a better thermal balance sheet and no consumption of fuel when standing, although the fuel required is dearer. The use of an electric motor with accumulators which involves at least one or two supplementary transformations of energy would appear to be less useful when compared with the use of thermal motors, with electric or mechanical transmission.

Avoiding or simplyfying terminal charges not only produces an economy in the charges involved but increases the availability of the stock, and consequently its possible mileage, and diminishes the staff and financial charges per train-kilometre. From this point of view rail motor coaches are better than locomotives as with them neither turning nor running round the train is necessary.

Such considerations lead to a solution of the problem being sought in the rail motor coach, the knowledge of other elements making up the hauling charges, *i. e.* upkeep and repair costs, as well as the financial charges, being ascertained from experience.

Up to the present in most cases the less frequented trains have been worked by more or less light steam locomotives. This has the advantage that such locomotives can be used for both passenger and goods services and for shunting, while fluctuations in traffic can be easily covered. The idea of a « light » locomotive is however purely relative; what is considered a « light » locomotive in these days would not have been so considered in the past; alterations in the classification of locomotives, the consequence of the gradual increase in train loading on many railways, has greatly increased the stock of « light » engines; such locomotives are no longer made, and those used for small trains are still often of the saturated steam and simple expansion type for this reason, and nearly always require both driver and stoker. Moreover it does not appear possible to confine the driving to a single man on somewhat well frequented lines.

Steam motor coaches in service on different railways before 1914 have entirely or practically disappeared, as they were not satisfactory. It would seem that the only exceptions have been those of the French Nord and the Great Northern Railway which, in reality, are

light trains composed of a motor and separate carriages which remain coupled together except when being repaired. In those of the Nord Railway the motor is between two carriages and, on the Great Northern, at the end of a train of one to four carriages. In this case, they are driven either from the locomotive or from the driving compartment of the carriage at the other end according to the direction of running. The rail motor coaches of the Nord Railway are driven from the foot-plate of the motor from which the driver can see in both directions. In the main, these rail motor coaches are the same as the « motor trains » which Mr. Nicholls says have replaced steam motor coaches on the Great Western Railway (Great Britain).

However, on the railways of England, France, America and Africa, steam motor coaches, such as the Sentinel and the Clayton, have in fact made a reappearance; these motors are worked by two men except in France where however only one motor coach of this type is mentioned. These vehicles have been introduced too recently for any estimation to be made as to the extension of their use.

This also applies to motor coaches fitted with an explosion or a Diesel motor, with electrical or mechanical transmission, which can be driven by a single man. At the present the attention of the railways appears to be chiefly fixed on the Diesel motor coaches, especially those with electrical transmission. The Diesel motor seems to be more flexible, and consumes a relatively cheaper fuel, but this is counterbalanced by the first higher cost of the motor. Probably for small powers and short daily journeys, when the cost of fuel is of less importance than the financial charges, the explosion motor is more economical than the Diesel. However on many railways those services which can be worked by a rail motor coach involve the use of large capacity cars of at least 100 to 150 H. P., which can haul one or two trailers, and this favours the Diesel whenever the journey is long enough. The saving from the Diesel over the explosion motor coach can moreover be lessened by such methods as those applied in Italy (Aliverti carburettors), or by using some other fuel than petrol, such as suction gas. Trials of this sort have been announced, especially in France.

The use of rail motor coaches with electric accumulators is only mentioned in Germany, and in Canada where, on the Canadian National Railways, however, their replacement by petrol motor rail coaches with electric transmission is under consideration, as their radius of action is too small.

The use of internal combustion rail motor coaches does not give rise to any particular difficulties; usually such vehicles are stabled in the ordinary locomotive depots, though care is taken not to put lighted up steam locomotives and petrol motor coaches together. In the case of Diesel motor coaches there is no danger of fire. The boilers of steam motor coaches have given trouble, at any rate the older types; the Sentinels and Claytons seem to be more satisfactory.

However, all these kinds of vehicles have not been in service long enough for any estimation of their upkeep and repair costs to be made, nor for fixing the exact time required to pay off their cost price.

This last point is important because of the high first cost of rail motor coaches. The influence of financial charges on the train-kilometre cost is however mitigated by the relatively great distances that can be covered annually by these rail motor coaches.

It must also be noted that in general their speed is greater than that of the steam trains they replace. Advantage

has been taken of this by stopping at additional halts without increasing the previous time taken by the whole journey; moreover very little expense is incurred by providing these new stopping places, because the total length of a rail motor coach is so short. The time gained by suppressing the terminal operations of turning and cleaning fires enables a greater number of journeys to be made. When these new facilities are offered to the public on a line where traffic is small because of motor competition, an increase or recovery of traffic can be hoped for, which will reduce working losses or even turn them into profits.

From the reports as a whole the following conclusions can be drawn :

1. The motors most used in train working on those lines of the great railways with little traffic and the little frequented trains on the more important lines are steam locomotives of more or less light weight, of the ordinary types.

2. Many of the railways also use rail motor coaches with or without trailers, with a steam or internal combustion (explosion or Diesel) motor, the power usually reaching 100 to 150 H. P., or more, and in addition Diesel locomotives. There is a marked tendency to extend the use of such vehicles. However their introduction is of too recent a date for definite conclusions to be formed concerning the economies resulting from their use.

3. It is quite usual for vehicles fitted with an internal combustion motor to be driven by a single man; steam locomotives are usually worked by two men.

4. It is not possible to form any conclusions as to which system is to be preferred since those elements for an estimation of their value, which only a long trial can supply, are wanting.

B. — The use of special tractors for shunting in smaller yards and for certain work in large yards.

Shunting operations in less important stations consist in shunting out wagons from the unloading yards and warehouses and their sorting with a view to attaching them to passing trains, or inversely placing in position, in the yard sidings, the wagons left by such trains; branch working; working wagons to the weigh bridge, to the loading dock or to goods collected in a station, awaiting wagons.

In medium sized and large stations there are similar shunting operations in certain sections, the movement of wagons in the transhipment sidings and, in the sorting sidings, such operations as pushing trains up to the shunting hump, and working wagons out of the marshalling sidings, etc.

The operations enumerated in the first place are usually carried out by train engines and consequently the standing time is increased resulting in loss in the turn round of the wagons and in the employment of the train staff. Furthermore shunting operations are not carried out at the best times but at such hours as suits the timetable. For these reasons there is delay in placing the wagons at the disposal of consignees and consequently a slower turn round of stock. Furthermore, light shunting is carried out by heavy and costly locomotives and so lowers the efficiency. Finally, prolonged halts diminish the average speed of the train, augment the number of working timetable intersections and are therefore the indirect cause of reduced output from the staff, locomotives and stock.

It is true that it would be possible to send a light locomotive from station to station to carry out the operations in question, but the unproductive journeys would increase the hourly shunting costs, occupy the line and only remedy

part of the above mentioned inconveniences.

The ideal is to have a shunting engine of small cost permanently at the station, which would not involve too heavy capital charges per hour of service and could be worked by the station staff. The kind and quality of such machines would of course vary according to the amount of service expected from them.

The simplest machines are capstans, sometimes hydraulic, usually electric, the use of which is mentioned by several reporters. The starting pulls are from 1 200 to 2 000 kgr. (2 640 to 4 400 lb.), the normal pull is a third of this amount at speeds of from 0.50 m. to 1 m. (1.64 to 3.28 feet) per second. The ropes which have a length of up to 100 m. (328 feet) are usually of hemp or jute, as wire ropes might injure the men. Capstans cost little to install and work, but their sphere of action is very limited.

Many railway companies use transporters, especially for operations in the transhipment sidings where the use of points is not advantageous or even possible. These electric transporters without pit are especially useful for taking out from, or adding wagons and carriages to trains in dead-end stations.

Among traction methods not confined to one fixed place or limited in movement, the reports mention horse traction, but this has nearly everywhere been replaced with economy by other methods, by capstans and above all by locotractors with steam or internal combustion motors, or by electric locotractors driven by accumulators, and finally by electric road tractors. Obviously on electrified lines electric tractors fed directly from the overhead lines are used.

The use of a recently constructed steam tractor fitted with steam engines of the motor car type (Sentinel) is mentioned by Mr. Nicholls. This tractor is driven by a single man; its H. P. is 100. The French Nord Railway still possesses four steam tractors furnished with a capstan, which were introduced forty years ago.

The internal combustion motor, always ready for work, consuming no fuel during stops, and easy to handle, is especially favoured for the unimportant and intermittent operations chiefly considered here. The use of electric accumulator locotractors is also stated to be economical by Mr. Leibbrand, but Mr. Hunziker finds them less useful because of their high upkeep costs and the necessity for a recharging depot. The explosion motor is employed more frequently than the Diesel; the cost of fuel consumption does not, as a rule much enter into the question. However trials are mentioned with the object of decreasing this cost in the case of internal combustion motors, especially in Italy and France, by the use of a mixture of petrol and oil (Aliverti carburettor), or of generator gas from wood charcoal.

Mr. Leibbrand finds that the Diesel motor not only has the advantage of consuming a cheaper kind of fuel, but that it is less affected by cold and requires fewer precautions against fire.

The locotractors have two axles, generally both driving, to get the adhesion wanted. This is sometimes increased by letting the tractor take part of the weight of the adjacent wagon. However such a method does not seem to be economical because of the loss of time taken in coupling it up; it is better to ballast the tractor.

The power of the locotractor varies from 25 to 100 H. P. and more; transmission is usually mechanical, rarely electrical. The maximum speed is from 20 to 40 km. (12.5 to 25 miles) per hour. Generally in the case of mechanical transmission, four speeds are provided, beginning at 4 to 5 km. (2.5 to 3.1 miles) per hour; but there are some types with as many as 12 speeds, be-

tween 1.5 km. (0.93 mile) and 40 km. (25 miles) per hour. The maximum tonnage hauled on the level is usually at least 200 tons. It must be possible to reach high speeds when the same engine is used in several stations and has to travel from one station to another in intervals between trains. If at the same time they are used, as on the French Est Railway, to work wagons from one station to the next so as to diminish the number of stops for the pick-up trains, they must be of relatively high power so as to run at sufficiently high speeds on the line.

The locotractors are usually furnished with air- and screwbrakes.

Several examples of the appreciable savings due to their use are given in the reports. One particularly interesting case is that of the St-Lazare Station at Paris, where steam locomotives have been replaced by petrol locotractors so as to avoid the nuisance caused by smoke.

It must also be remarked that the locotractor can be used in places inaccessible to locomotives and can be turned on the wagon turntables.

In England, America, France and Spain, road tractors are also used in the stations to replace horse traction and traction by rail locotractors or locomotives, over which they have the advantage of being more flexible as they are independent of the track.

They require a paved or specially prepared track; they have rubber tyres. Systems using caterpillar or other tracks have not given good results.

The most remarkable use of road tractors is reported by the French Est Railway, for buffering up of wagons in sidings; the special tractor used in this case runs between the tracks, replacing a locomotive and considerably increasing the work done over the hump, *i. e.* the output of the marshalling yard.

The loss of output due to shunting engines closing up the wagons is estimated at 25 %, and even more by Mr. Leibbrand, the inventor of a process somewhat similar to that used on the Est Railway. Mr. Leibbrand makes use of an electric battery tractor on rails of 0.75 m. (2 ft. 5 1/2 in.) gauge placed between the tracks; he also mentions the Bäseler system using cables driven by an electric motor which is cheaper to instal and has given good results. An application of traction by rope haulage for working the rakes of wagons to the hump has been worked out in a German yard; but this is rather in the domain of the mechanisation of the hump.

The statements of the various reports may be summed up as follows :

I. — The engines whereby shunting in small stations and certain operations in important stations can be cheaply performed, are :

1. Electric capstans, alone or in conjunction with turntables; electric transporters and transporters hauled by a tractor capstan or locotractor. The tractors are especially valuable for shunting on lines to which access through the points is not possible.

2. Locotractors with or without a capstan and worked by a single man. These locotractors are usually fitted with an explosion motor, sometimes with a Diesel or steam motor or with electric motors with accumulators.

They can be run on any track accessible to wagons.

Petrol, Diesel and accumulator tractors have the advantage over steam locotractors of being always ready for work, and can be driven by the ordinary station staff.

3. Road tractors with rubber tyres independent of the track and therefore very flexible in use. They are particularly suitable for operations otherwise carried out with the help of horses.

II. — Horses have practically ceased to be used for traction purposes.

[656. 1 & 656. 2]

SECTION IV. — GENERAL.

QUESTION XIII.

(COMPETITION OF ROAD TRANSPORT) [1]

by Dr. ALEXANDRE WASIUTYŃSKI,

Special Reporter.

CONTENTS.

I. — Foreword.

The object of the present report is to sum up the five reports sent in on the question of motor road transport competition :

Report No. 1 (America, China and Japan), by Mr. C. B. SUDBOROUGH [2].

Report No. 2 (Belgium, France, Italy, Portugal, Spain and their Colonies), by Messrs. LE BESNERAIS and DEGARDIN [3].

Report No. 3 (British Empire), by Mr. H. L. WILKINSON [4].

Report No. 4 (other countries except Germany), by Dr. A. WASIUTYŃSKI [5].

Report No. 5 (Germany), by Dr. ZIETZSCHMANN [6].

So as to be better able to compare the various statements in respect to the different countries, as well as the opinions of the reporters about each question, the reports on these questions have been summarised in the order of the questionnaire which was sent to all the Railway Companies concerned.

The complete text of the questions will be found in reports Nos. 2 and 4.

II. — General Report.

1. — Importance of motor traffic in the country.

The total number of motor vehicles in circulation in the United States in 1927 was 23 000 000, i. e. about 80 % of the total motor vehicles of the world. From 1920 to 1927 inclusive the increase in the total number of registered vehicles was 145.9 %. In the United States there is one motor vehicle for every five people, and this extraordinarily high proportion is continually increasing.

In Europe the number of people per motor vehicle is very much greater and varies from one country to another, from 38 in Great Britain, 43 in France, 46 in Denmark and 112 in Germany, up to nearly a thousand. However, in every country the number of motors in circulation has rapidly increased in these last few years with the result that since 1921, in many countries (Belgium, France, Great Britain, Italy and others), their number has more than trebled, while in Germany it is even four times as great.

In most countries there are no official statistics as to motor traffic available with the result that many of the facts

(1) Translated from the French.

(2) See *Bulletin of the Railway Congress*, June 1929, p. 767.

(3) See *Bulletin of the Railway Congress*, November 1929, p. 2605.

(4) See *Bulletin of the Railway Congress*, August 1929, p. 1287.

(5) See *Bulletin of the Railway Congress*, December 1929, p. 2877.

(6) See *Bulletin of the Railway Congress*, January 1930, p. 191.

relating to the subject are missing and have to be deduced from other sources of information.

2. — Regular motor services in the area of a railway.

In most countries regular motor services have reached a high stage of development. In the United States their extent is pretty much the same as that of the railways, as also in Germany, Switzerland and Czechoslovakia. In Denmark, France, Italy, Norway, Poland and Sweden they are from 2 1/2 to 3 1/2 times as extensive; in Portugal they are 10 times as extensive. In Germany 36 700 km. (22 800 miles) of regular motor services, or almost two thirds of the whole, are owned by the Post Office.

The average extent of a service is usually from 25 to 35 km. (15.5 to 21.7 miles), in Germany 18.5 km. (11.5 miles), while only in Switzerland and Belgium does it fall below 15 km. (9.3 miles). In the United States where there are motor services of from 368 to 2 260 km. (229 to 1 404 miles) in the 14 States which sent in replies, 50 % of the bus services are less than 32 km. (20 miles) long, and 75 % less than 48 km. (30 miles). The average cartage services are about the same. The total length of the regular motor services in the United States has increased very rapidly during the last few years; indeed the annual increase is often as much as 25 % or even more.

3. — Competitive motor services.

The extent of the competitive motor services in comparison with the total extent of motor services in districts served by the railways differs very much from one country to another.

In the United States (14 States treated in detail by Mr. Sudborough) it is estimated that 41 % of the motor services are in direct competition with the railways, 28 % in indirect competition, while 31 % in no way compete with the railways.

Messrs. Le Besnerais and Degardin state that, as far as competition against the main lines is concerned, the proportion of existing motor services in competition falls to about 10 % in thinly populated regions where railway stations are far apart, while it is more than 80 % in thickly populated districts of great industrial and commercial activity. In the case of small local railways or certain branch lines of the great railways however it is quite another matter; here there is often direct competition under circumstances greatly in favour of the motor services.

Information from other countries (report No. 4) confirms this statement. However it appears certain that proper legislation concerning motor services is making the competition of such services practically negligeable even in countries like Switzerland, that are densely populated and well served by the railway.

4. — Traffic of the competitive motor services.

According to Mr. Sudborough's report, in the United States bus services run by public transport services other than the steam railways carried about 1 100 million passengers in 1928. About 2/3 of these services were in direct or indirect competition with the railways. In the same year in the United States the railways carried 902 million passengers. As the average journey of railway passengers in the United States is 45 km. (28 miles) and that of the road passengers only 26 km. (16.2 miles) it follows that the passenger-kilometer traffic of the United States competitive motor services may be estimated at about 40 % of the railway traffic.

According to the report of Messrs. Le Besnerais and Degardin this same proportion may be established as 0.34 % in France. In the case of the small rail-

way whose length of service is of the same order as that of the road services, the relation between the traffic of the two services is often in favour of the road.

In Germany the journeys of motor passengers are about 4 %, in Norway and Poland about 5 %, of those of railway passengers. Information concerning the traffic of other countries is not available.

In the case of goods traffic, according to Mr. Sudborough's calculations, the kilometric tonnage carried by motor lorries in the United States on town to town services during 1925 was only 1.9 % of the kilometric tonnage carried by the railways.

The importance of the goods traffic in kilometric tonnes of the regular competitive motor services in France is shown by its proportion with railway traffic, this being from 0.02 to 0.08 %.

In the replies dealing with other countries this kind of transport was included amongst irregular and intermittant goods transport (No. 8 below), it being often difficult to distinguish between them.

5. — Legislation concerning competitive motor services.

a) *Administrative authorisation.*

In the United States, bus services classed as public transports which do only run within the limits of one State are under State control in 44 of the 48 States, but bus services from one State to another, to the number of more than 2 500, are not at the present under any sort of State control. Proposals for a law to control such enterprises has been laid before the Congress.

In nearly all the countries of Europe the running of regular motor services necessitates an authorisation (license-concession) from the responsible authorities.

In Belgium the creation of regular passenger services must be approved by the King.

In Italy the regular motor services are the object of a concession, in Spain only the regular passenger services.

In Switzerland a concession is granted for ten years. Enterprises which have obtained a concession come under the laws concerning the civil responsibility of railway enterprises as well as the laws concerning the hours of work, and they are obliged to insure their staff.

In Tunis the regular services are placed under the regulation of either the terms of their concession with State subvention or of the ordinary authorities.

In some other countries (Germany, Denmark, Finland, Holland, Poland, Sweden, Czechoslovakia), the working of regular passenger services necessitates an administrative authorisation from the State department, in certain cases of the Minister of Public Works or with his approval, after inquiry has been made into the necessity for such a service and its importance as regards the existing means of transport.

In Germany and Switzerland, the Post Office has been given the right to work regular bus services.

In Belgium, Holland and Switzerland, no particular authorisation is required to work regular goods services.

In France all that is necessary to work a motor service is the making of a declaration to the Prefecture and the keeping of safety regulations.

In Greece, Portugal and the Dutch Indies motor traffic is under no special control.

Details concerning regulations for regular motor services in Great Britain and the United States were not given but what regulations there are, are known to be very free.

The answers of some countries (Denmark, Poland, Switzerland) show that preparatory work relating to the legisla-

tion of motor traffic or to changes in existing legislation, is in hand.

b) *General plan.*

No general plan for regular motor services with the object of assuring public interests exists in any country, except perhaps in the Dutch Indies (Sumatra Railways) where all such services belong to the State. The concession-holders are free to choose the routes of the services they wish to run, but with a few rare exceptions their requests for authorisation are judged according to the necessity for such services and the existing means of communication, so that in regions where the services are considered sufficient, no further authorisations are granted.

In Switzerland the concession-holding services serve districts that have no access to the railway and are therefore a useful complement to the railways. No concession would be granted to any motor service that would seriously compete with the railway.

c) *Subsidies.*

Subsidies from the public authorities are only granted in France, Italy, Norway and Switzerland.

In France a great many services receive subsidies from the communes and departments and the State bears a part of these when the service is not in competition either with other motor services already subsidised by it or with the railway services.

In Italy subsidies are only granted to services that have a definite concession for 9 years.

In Norway subsidies are granted to regular motor services in thinly populated regions where communications are poor.

In Switzerland these subsidies are only granted in certain cantons and for the most part take the form of repayment by the public authorities of part of the running losses.

According to official information (Report No. 5, IV 3) motor transports in Germany also greatly profit by public subsidies from the States and Communes, but the conditions under which such subsidies are granted is not known.

d) *Participation in road expenses. Taxes.*

In every country except Italy, the regular motor services share in the road upkeep expenses by the payment of taxes, the returns from which are set aside for this object and sometimes also cover the expenses incurred in making new roads. Vehicles are taxed according to weight (sometimes according to weight and mileage), and there are taxes on tyres, petrol.

In their report, Messrs. Le Besnerais and Degardin show that the taxes paid by motor vehicles in France are very far from paying for upkeep expenses and capital charges incurred in road construction, while in Belgium, Spain and Portugal the taxes collected for road upkeep expenses only represent a small part of the expenses.

In other countries also statistics concerning the taxes paid by the motor services show that they bear but a small part of the road upkeep expenses.

In Germany, according to Dr. Zietzschmann's report, the tax on motor vehicles, the only contribution they make towards road upkeep expenses, covers less than one third of these upkeep expenses alone, without taking into account the interest of the paying off of constructional expenses.

In contrast with this in certain countries, the railways have to support very heavy taxes over and above their upkeep and construction expenses.

In Spain, the railways pay a tax of 25 % on passenger traffic and 5 % on goods traffic.

In France the railway companies have

to pay a tax of 32.5 % on passenger traffic and 65 % on supplements for seats in special luxury vehicles, while on goods traffic there is a tax of 10 % which is reduced to 5 % in the case of certain goods of small value or for immediate consumption.

Mr. Wilkinson points out the heavy legal charges laid upon the British railways. According to the law of 1921, taxes and rates must be fixed in such a way as to produce a net return equal to the net product of the receipts of 1913, account being duly taken of post-war expenses. If the receipts of the taxes collected by the railways exceed the standard expected revenue, the surplus up to 80 % is returned to the public under the form of a reduction in rates. On the other hand the railways pay local taxes, the total value of which is 17 % of their net receipts. These taxes provide the means to cover the surplus expenses of road improvement and upkeep which are greatly in excess of the amounts paid by the road transport companies under the form of licensing dues. In this way the railway companies help their competitors by means of the local taxes they have to pay.

In Germany, according to Dr. Zietzschmann, the railways pay a tax upon traffic which rises from 11 to 16 % on the price of tickets and is 7 % on the rates for the transport of all goods except coal. On the other hand, as far as motor traffic is concerned, only the transport services pay a registration and stamp tax of 0.75 %, industrial concerns and private individuals being exempt. By these laws a notable reduction in the cost of travelling or transport is given to people using the motor services instead of the railways.

e) *Approval of rates.*

In most countries (Belgium, Denmark, Spain, Finland, Italy, Norway) the passenger and goods rates of regular motor services, in Germany, Holland, Switzerland and Czechoslovakia the passenger rates, in France the rates of subsidised services only, are fixed by the authority giving permission for the service (license-concession). In Sweden the authorities fix a maximum for the passenger and goods rates. In Greece and Poland all road undertakings are free to fix their own rates.

f) *Monopoly or free competition.*

In no country, except Spain and Italy, do concessions (license-authorisation) count as a monopoly. But while reserving the right to grant concessions to other services running over the same routes, unfair competition is avoided.

In Spain the concession of a regular motor service forms a monopoly for 20 years.

In Italy the concession of subsidised services gives a monopoly for 9 years while for other services there is possibility of competition, but the Government is always free to prevent it.

g) *Preferences for obtaining concessions.*

In no country are there any undertakings which enjoy the right of a preference for obtaining the concession of regular motor services, except perhaps in certain cases in Germany, Belgium and Italy.

In one of the German States it is the rule that in cases where it is recognised that the projected service would compete with the railway, the railway company must be asked if it wishes to work the new service itself. Dr. Zietzschmann observes that the German laws relating to concessions tend rather to prevent the railways from making use of motor vehicles themselves than to protect them from harmful competition.

In Belgium, the National Light Railway Company enjoys a preference for obtaining the concession of certain ser-

vices when the services asked for would function along routes forming part of its own projected lines, when they follow its existing lines or join two points served by its lines.

In Italy, the concession holders of regular services enjoy a preference for the concession of adjacent services and the operators of provisional services can turn these into definite concessions.

It is to be noted that in Switzerland State enterprises and large private enterprises usually obtain the preference in view of the greater financial guarantees they offer.

6. — Motor service rates.

In no country are there fixed laws for determining the rates of regular motor services, and these rates vary very much according to the conditions of working and the competition of other kinds of transport.

In the United States the price of a seat in a bus is usually the same or higher than the price of a railway ticket for a short journey, but definitely lower for a long journey [for a journey of 2 250 km. (1 400 miles) as much as half]. The usual price of passenger tickets on steam railways is 11.6 gold-centimes per km. (18.7 gold-centimes per mile).

In European countries the average passenger fares of the motor services in gold-centimes per km. (per mile) are approximately : Denmark, Norway, Sweden 14 (22.5), Spain 11 (17.7), Germany 10 (16.1), Italy 9.5 (15.3), Czechoslovakia 7 (11.3), Poland and Jugoslavia 6 (9.6), France and Belgium 5.5 (8.8).

These fares approximate 2nd class railway fares in Belgium, Denmark, France, Norway and Sweden; they are 60 % higher in Spain, and 35 % higher in Italy; they are about 40 % lower in Poland, Portugal, Czechoslovakia and Jugoslavia.

Rates for the transport of goods by motor lorries are still more variable than the bus fares.

In the United States transport by motor lorry for distances up to 48 or 80 km. (30 to 50 miles) is usually lower than the railway rates; but it is higher than the railway rates for distances greater than 80 or 160 km. (50 or 100 miles) respectively.

Messrs. Le Besnerais and Degardin state that generally the rates of motor goods transport services in the countries covered by their report are determined by those of the railway and are always a little lower than these.

In other countries the prices of motor transport per tonne-kilometre (per English ton-mile) are : in Norway 83 (136) gold-centimes [by railway 11 to 12.5 (18 to 20.4)]; in Sweden 70 to 101 (114 to 165) gold-centimes; in the Dutch Indies (Java) from 30 to 60 (49 to 98) gold-centimes. In Switzerland the average cost of goods transport by rail is 1.20 (1.96) gold-francs per 10 tons and 0.90 (1.47) gold-franc per 5 tons. The motor services are on the average 15 to 25 % cheaper.

In Germany, according to Dr. Zietzschmann's report, the transport rate by motor lorry is from 12 to 37.5 (19.6 to 61.3) gold-centimes on an average of 19 gold-centimes per km. (31 gold-centimes per mile) without counting loading expenses, while that of the railway, including the cost of sending goods in small packages, is on the average 5.75 (9.4) gold-centimes.

Dr. Zietzschmann gives no information about the rates of the transport of packages by rail, in Germany, which is doubtless greatly higher than cost price. On the other hand he states that the lorry rates are often below cost price.

7 and 8. —Effects of the competition of regular motor services and of motor transport in general.

Mr. Sudborough states that it is impossible to determine exactly what propor-

tion of the American railways' loss of traffic is due to motor traffic because of the lack of statistics on the matter of motor transport. He establishes two general facts :

1. In the last eight years, 1920 to 1927 inclusive, the railway receipts from passenger traffic have decreased, and an exact relation can be established between this diminution and the increase in the number of motors belonging to private individuals plus the increase in the number of buses.

2. A large goods tonnage once carried by rail and could be yet, is now carried on the roads by motor lorries.

The total 1st class passenger receipts of the United States Railways for the eight years 1920 to 1927 inclusive have diminished by $ 311 663 000, this representing a loss of 24.2 % while the total population of the United States has increased by more than 6 % and people have been travelling much more than they used to, so that consequently the total number of potential railway passengers is continually increasing. On the other hand, during the same period of eight years the total number of registered motor vehicles has increased by 145.9 %. Consequently it must be concluded that all the passengers lost by the railways now make use of motor transport.

Though the diminution in passenger receipts has been felt by all the railways, the short lines have suffered the most. This is verified by the experience of the Pennsylvania Railroad which runs the greatest number of « limited » passenger trains in the world on its 18 702 km. (11 620 miles) of lines. The diminution in the passenger receipts of this railway in 1927 was only 7 % while for the whole of this class of railway in the United States it was more than 24 %. At the same time the West Jersey and Seashore Railroad [480 km. (300 miles)] which is worked as a subdivision of the Pennsylvania Railroad and joins Philadelphia to many important seaside resorts, has lost 36 % of its total number of passengers and 27.8 % of its passenger receipts, despite its useful and frequent service and its express trains which run up to 97 km. (60 miles) per hour.

As for goods traffic, the kilometric tonnage of motor lorries on the intertown services in the United States only represents a small percentage of the kilometric tonnage carried by the railways. The proportion of tonnage transported by lorry tends to diminish as the distance increases. This is shown by an analysis of rail and road tonnage between thirty towns in the State of Ohio situated at distances of from 11 to 216 km. (7 to 134 miles). For distances of less than 2 km. (1.2 miles), 84.5 % of the total tonnage was transported by motor lorry. This proportion decreased inversely with the distance up to 2.3 % for distances of more than 160 km. (100 miles). At the same time rail tonnage increased both as regards complete and partial loads. No appreciable rail tonnage in part wagon loads has been observed above 64 km. (40 miles).

Mr. Sudborough remarks that if during these last few years the passenger-traffic has diminished the United States steam railways have been called upon to carry a continually increasing amount of goods traffic, and the remarkable expansion of the motor trade has been one of the chief factors in this continual increase. The 1925 statistics on industrial products revealed the fact that motor vehicles are the first industry of the United States. In 1927, the United States railways transported 757 388 complete loads of motors, lorries, and accessories, this being the third most important dispatch by rail of industrial products. In the same year 3 267 388 full loads clearly attributable to the fabrication and use of motor vehicles were transported by rail. Citing these facts and following the opinion of many of the most competent

judges, Mr. Sudborough arrives at the conclusion that the motor industry has become one of the railways' best customers, and that the railways of America have in reality gained by the creation and development of the motor industry.

According to the report of Messrs. Le Besnerais and Degardin the railway companies have felt a diminution in passenger traffic without however being able to ascertain the amount of this, that can be put down to motor competition. Motor road transport appears to be particularly serious in the case of the secondary lines and smaller railways, which the bus service tends to replace. In the case of the great French Railway Companies the relation between passenger road and rail traffic in kilometric units is 0.22 to 0.57 %, while certain lines of the secondary French Railways have suffered a loss in the number of passengers of from 20 to 5 % through the competition of buses. The Italian Emilia Railway shows a loss in passenger-kilometres of 14 % from 1926 to 1928.

Motor passenger transport competition apart from the regular motor services is especially important when it is a case of assuring service by private individuals themselves. The great railways estimate their losses from such competition as between 0.05 and 2 % while the light railways show a decrease in traffic of 15, 25 and even 60 %.

In the case of goods traffic the great French railways estimate the relation between the traffic of the regular motor services, in kilometric units, and the railway traffic for the whole of the lines of every company as 0.02 to 0.08 %. The secondary French lines have suffered a loss of from 10 to 20 %, the Algerian lines on short distance routes a loss of 50 %.

Motor goods transport competition apart from the regular services includes a multitude of transports for all kinds of distances and it is hard to estimate its effects on railway traffic. In the regions served by the French Nord Railway the relation of the real tonnage of motor transport over distances equal to or above 20 km. (12.5 miles) to the tonnage transported by the railway was estimated at 0.31 % for 1927.

In Great Britain an analysis of the tickets taken by passengers for journeys of varying lengths on the London Midland & Scottish Railway has shown a diminution in receipts from 1925 to 1927 in inverse ratio to the distance, which indicates that the loss was chiefly due to road competition. For distances up to 8 km. (5 miles) this diminution was 21.19 %; above 320 km. (200 miles) it was only 1.55 %. In the same way on nearly all the branch lines which represent short distance traffic, the passenger receipts have greatly decreased. The North Western Railway (India) has stated that wherever a route is shorter by road than by rail the decrease in the number of Inter and 3rd class passengers is nearly 50 %. On one important suburban line in South Africa the passenger traffic has decreased by 14 % despite recent improvements which include the electrification of the line. On another suburban line of this country the great decrease in passenger traffic has resulted in the cessation of the electrification of the line and a bus service has been substituted for it. On certain British railways the receipts from milk trains have shown a diminution of 16 to 22 % during the last four years.

In the case of goods traffic in the zone served by one of the British railway companies according to the statistics, the transport by road has been estimated as :

57.8 % of the traffic between places 64 km. (40 miles) apart or less;

18.5 % of the traffic between places more than 64 km. (40 miles) away;

23.7 % of the traffic in important districts with a well coordinated system of distribution by vehicles, belonging to the competitors, or by industrial vehicles.

The Swiss Federal Railways state that

the competition of the few adjacent motor services has no great significance for them in the case of either passenger or goods transport.

In Poland the passenger traffic of competitive motor services expressed in passenger-kilometres is estimated as 5.5 % of the passenger traffic of the railways against whom there is competition.

The annual losses in passenger traffic receipts due to the competition of all motor traffic is estimated in Switzerland, Czechoslovakia and the Dutch Indies (Sumatra) at about 8 %, in Norway at 12.5 %, while in Holland it is perhaps as much as 17 %. In Sweden several local railway companies have suffered a loss in passenger traffic of from 20 to 40 %, since 1913, this being certainly due to motor competition. The railways of Finland, Czechoslovakia and Yugoslavia state that there is diminution in passenger traffic only in the case of short routes while the total passenger traffic is increasing.

Losses in goods traffic occasioned by motor competition are estimated at 6.85 % of the total receipts in Norway, 10 % in Switzerland. The Swiss Federal Railways state that the competition of regular motor services is of no importance for this traffic and that the greater part of the transports lost by the railway are now carried by commercial and industrial firms on their own behalf or accessorily on behalf of a third party, and also by transport enterprises according to the needs of their customers. The situation in Holland is exactly similar.

Dr. Zietzschmann estimates the losses of the German railways in 1928 in passenger traffic at 140 to 150 million Rm., and in goods traffic at 180 million Rm., of which 30 millions were due to bus traffic, i. e. in passenger traffic 10 %, 2.2 % of this due to bus services, and in goods traffic 5.7 % of the receipts. In making this estimate, account has been taken of the profits brought to the railways by bus services acting as feeders. This profit is negligible as far as goods traffic is concerned, since the chief advantage of using lorries, except in the case of purely local services, is the avoidance of transhipment. As for the individual profits which the railways might obtain from motor industry transports the German railways explicitly deny the existence of any such profits. It is simply a question of industrial changes and even if there were an increase in industry and in the resulting transports it would be largely counterbalanced by the regression in transport of a higher class.

9. — Improvements in rail transport to combat motor competition.

Mr. Sudborough in his report about the United States railways gives no answers to question 9 of the questionnaire. The means applied to this end in the United States which he gives in quoting the programme of the Pennsylvania Railroad are of another order and should be considered under Nos. 12, 13 and 14. From this it may be concluded that in the United States improvements in rail transport to combat motor competition have already been exhausted or that those which it would be possible to make, are judged to be of little importance.

Messrs. Le Besnerais and Degardin remark that, in the opinion of certain railways (Spain, Portugal, and the minor railways of Belgium), as far as passenger traffic is concerned, the motor has the advantage of being quicker and more comfortable and that there is need for the speeding up of trains and the renewal of stock. But in spite of this the railway would still have many failings : too few trains, too few stops [1], service too much confined to the actual track. Messrs. Le

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[1] To make good the inconvenience of too few stops the Italian Emilia Railways have organised supplementary shuttle service trains which stop whenever passengers want them to.

Besnerais and Degardin observe that the total correction of such failings would indeed be difficult and burdensome. Sometimes the use of motor rail coaches is a solution, especially in the case of secondary lines, but their output is too often limited by the impossibility of making use of them except on morning and evening trains. Therefore they consider that it would be best in many cases to suppress the railway service more or less completely on these lines, replacing it by a road service which would have the advantage of workng in small units, at frequent intervals and relatively quickly. All efforts should be directed towards a close collaboration between rail and road. To the share of the motor should fall those services where the number of passengers is not great, services between stations, new services and tourist services; on the other hand the railway should keep the long distance services where it insures greater rapidity, comfort and security, and the very crowded services. To make good the loss of traffic resulting from the competition of privately owned motors the French Railway Companies have offered the public an express transport of motor vehicles at specially reduced rates, a measure which has given appreciable results and could be further improved by the creation of motor hire centres in tourist regions.

In the case of goods traffic there is competition above all as regards express transport, transport of light goods and small consignments for which the capacity of a motor vehicle is better suited than a railway wagon and the motor is able to go directly to the consignor or consignee. This competition can be combated by reducing delays in transport, tonnage conditions, extending the hours at which stations are open... The « grouper » (cartage agent collecting and delivering goods transported in bulk by rail) is a valuable adjunct to the railway; his role should be developed as it dispenses the public from the formalities of dispatching goods, simplifies or makes packing unnecessary, and leads to a unified door to door transport. As regards private services the publicity obtained by certain firms by the use of their own vehicles is unfavourable to the railway. But more often the advantage rests with the railway because the multiplicity of its operations enables it to make up heavy trains and to transport goods at notably lower rates than those charged by a large lorry. However the railway should follow the efforts of the motor as far as the facilities and satisfaction given to the public are concerned.

The Italian State Railways grant reductions in rates to important enterprises undertaking delivery by lorry.

Mr. Wilkinson's report contains a detailed enumeration of improvements carried out on the British railways to combat motor competition.

In order to arrive at a more intensive train service for passenger traffic certain companies have electrified their suburban lines. The Southern Railway states that in the electrified areas the number of the passengers' journeys increased by six millions in 1928 in comparison with 1927; receipts have increased by £ 213 000.

For the comfort of passengers, 3rd class sleeping cars were introduced in 1928; berths can be booked in these for a supplementary charge of 6 sh. Demands for these berths proved so numerous that other cars had to be constructed for the benefit of business men. In certain cases holders of ordinary tickets are allowed to break the journey. A system of luggage in advance has been introduced which consists in the collection of luggage from house or hotel, its transport and its delivery to house or hotel, a very important facility which is extremely popular.

To facilitate and accelerate carting between the parcels offices and the trains, stations of a certain importance

have been provided with electric and petrol lorries. On branch lines, besides the motor rail coaches, motor coaches have been introduced to which can be attached trailers and capable to assure the service at a low cost. Modifications have been introduced in the transport of packages. Tank-wagons have been provided for the transport of milk and a special reduction of 30 % is granted to this rapidly extending method of transport. Attempts are being made to improve the fast mail trains which have been run on the British railways for many years.

In Great Britain it has been recognised that in the case of goods trains, fast and frequent services are an essential factor in the struggle to keep the long distance traffic. There is a general increase in the number of fast goods trains between the chief industrial centres for distances of from 480 to 640 km. (300 to 400 miles). These trains which sometimes run more than 225 km. (140 miles) without stopping, have increased the sphere of the next day delivery services, i. e. traffic leaving a town on the afternoon or early evening which is delivered at its destination [320 or even 640 km. (200 or 400 miles)] away the next morning. A recent innovation as regards this traffic has been the publication of timetables of goods trains by the railway companies. One company has introduced a scheme for registered goods which are controlled in a special way from one place to another.

The cartage service of the railway companies is a very important factor among the measures taken to combat road competition. The British railway companies tend more and more to take charge of it themselves rather than to leave it in the hands of a contractor. By replacing the horse vehicles by motor lorries the sphere of action has been widened and a more rapid service is obtained. The extension of the lorry services has led to the introduction of country lorries which collect and deliver goods at shops, farms and houses within a radius of about 24 km. (15 miles) from certain stations. These lorries which run about the country in this way are at the same time an excellent publicity medium and distribute leaflets about the other advantages offered by the railway : cheap tickets, excursions, etc.

The equipment of depots and stations is being improved which enables a quick dispatch of goods to consignees. In densely populated areas, railway warehouses have been established in which regular customers can have their private depots. Traffic is consigned in complete loads at the lowest rate possible and can be distributed from the warehouse in small lots to the individual or the client himself. Certain running economies have been effected, as for example the uniting of neighbouring stations under a single stationmaster and by a reduction of staff.

The other railways (report No. 4) give as failings observed in the railway which cause preference to be given to motor transport, for passenger traffic : trains too infrequent and too slow, not enough attention paid to the smaller towns when the timetables are drawn up, inconvenient connections for cross country journeys, uncomfortable 3rd class carriages ; for goods traffic : lack of cartage at smaller stations, slowness of transport especially for short distances, formalities upon consignment.

Measures taken to remedy these failings in passenger traffic include first of all improvements in the timetables, especially the speeding up of trains and an increase in their number, this having been greatly assisted by the electrification of certain lines. The organisation of slow and frequent local train services by motor rail coaches and rail omnibuses on lines where there is not much traffic and allowing these to stop between stations is a more or less general measure. Improvements in the connections at junctions, the organisation of

through services on branch lines as well as the reduction of mixed trains and the organisation of special and cheap trains on holidays, are measures that have had much success.

In the case of goods traffic the acceleration of transport has been undertaken, and reforms have been made in the carting and the organisation of lorry services for collection and delivery. Transport has been accelerated by through goods trains, timetable improvements obtained by the reduction of the time spent on the journey and at stations, as well as quicker reconsignment from the reloading stations. In Switzerland on the main lines small packages are despatched twice a day each way and night labour has been introduced in the goods depots.

The use of most of such measures for passenger and goods traffic has been recognised by the German railways.

Cartage services, either alone or in collaboration with other enterprises, have been introduced or reorganised on several railways. In Switzerland a cartage service carried out by the railway staff has been introduced.

In 1926 the Swiss Federal Railways organised a company called the « Sesa » whose exclusive concern is the relations between rail and road; it intervenes in favour of the railway by keeping an eye on motor competition and maintaining it within certain limits. The cartage services have been improved, completed and made less expensive by this company which has also organised motor services to extend and improve transports between localities not served by the railway.

10. — Rating measures taken against motor competition

Mr. Sudborough's report does not give any particulars concerning the rates measures taken by the United States railways against motor competition. It cannot be doubted that such measures have been taken, but at the present they have lost their importance as compared with other means.

Messrs. Le Besnerais and Degardin remark that in the case of passenger traffic, motor competition is much less a question of price than convenience, frequency, speed and timetable; for this reason rates measures taken by the railways were rather directed towards the development of passenger traffic than against competitive services. Such measures especially apply to group journeys, return journeys, week-end and Sunday travelling, monthly season tickets between two places, general reduction in the price of season tickets, establishment or extension of family tickets, special tickets for seaside or watering places, extended validity of return tickets, less stringent regulations about breaking a journey, rapid transport of passengers' motor cars at a low rate, etc. Facilities in the form of through tickets or through booking of luggage such as are granted in France on certain tourist routes of mixed rail and road travelling show a spirit of collaboration between the railways and such motor services as act as feeders to them or extensions.

As far as goods traffic is concerned, after quoting some rates measures against motor competition taken by the Belgian National Railway Company and the French Railways, such as seasonal rates for shuttle services, reduced rates for empties, free transport of the ice accompanying certain commodities, premiums on tonnage and regularity, special rates for « grouped » goods, rates for door to door transport, Messrs. Le Besnerais and Degardin give a detailed analysis of the failings inherent in the principles of railway rating which impede the railways in their struggle with road transport competition. The very form of the decreasing scales of rates and the application of terminal charges

independently of distance, gives a severe handicap to transport over small and medium distances where road competition has its maximum sphere of action. Above all it carries with it a strict application of the principle of equality of treatment and the legal obligation of giving the rates, the price no doubt of the monopoly once enjoyed by the railway but a definite drawback in face of a new competitive service to which such a principle does not apply. « The railway rates must therefore be made much more flexible if equality is to be established between rail and road competition. » Messrs. Le Besnerais and Degardin remark that with this object in view it would first of all be necessary to be able to grant without delay all useful modifications in the conditions applying to consignments and to be able to limit the measures to be taken, whether it is a question of lowering the rates or of giving new facilities to clients, to those transports in which there is competition. The solution of fixed prices for definite relations and goods doubtless constitutes a first step in this direction which it would be necessary to continue by granting premium formulæ to tonnage and regularity more freely besides other facilities such as rapid transport conditions, the simplification of the packing required and of the different formalities at the station or the private siding, the rapid payment of charges, etc., in such a way as to keep pace with motor competition as regards the facilities it offers its patrons.

Mr. Wilkinson's report contains a detailed enumeration of the reductions and facilities given to passenger traffic in Great Britain. These reductions in certain cases enable a return ticket to be bought at the rate of 1 1/3 of a single ticket, or at times even of a single ticket (workmen's tickets). Special reductions and facilities are granted to tourists, guaranteed excursions, educational tours, cross country journeys, ordinary season tickets and railway employees tickets, motorists' tickets, etc. The age limit for childrens' half tickets has been raised to 14 years.

Passing to the rates measures taken to combat motor competition in the matter of goods traffic, Mr. Wilkinson states that in Great Britain it was possible in thousands of cases to reduce the rates so as to draw traffic to the railway or win back what had been lost, and that today such measures definitely prevent the loss of a considerable amount of traffic.

However the lowering of the rates must be set about with prudence since what is done in one area cannot reasonably be refused in another and it has been found that such measures, sufficient in a certain number of cases to revive the traffic, in others was not sufficient to raise the receipts to the same figures obtained by the higher rates.

In Italy, the Emilia Railway has passed agreements which give notable reductions in rates to consignors who guarantee a certain yearly tonnage of goods.

As far as the other countries are concerned (report No. 4) the revision and lowering of the rates with the object of lessening motor competition has been taken in hand during the last years by nearly all the railways, except the State Railways of Finland, Greece and Poland where the Companies find that the lowering of the rates on their railways would not make any change in motor competition which would profit the railway, as such competition would continue to develop because of other advantages.

The rates changes were carried out in the form of a lowering of the charges for passengers and packages for short distances, up to 100 km. (62 miles) (Norway and Sweden) or only for certain relations (Czechoslovakia, Dutch Indies). In Denmark, Holland, Switzerland and Czechoslovakia, in special cases the railway companies were authorised to make

agreements with their clients about transport rates.

In Switzerland the railways decided to carry, after the 1st April 1927, both express and slow goods at rates, including cartage, corresponding with the cost of transport by motor lorry, if the consignor can prove that without such a concession it will be cheaper for him to carry out his transports by motor lorry and that he is in a position to do so, and also provided that he agrees to have a certain minimum tonnage transported in the year and will cease to make use of motor lorries. The « Sesa » (cf. 9 above) is charged to negociate on this subject with the consignor. Dr. Zietzschmann remarks that if the lorry, in spite of a comparison so little in its favour, is able to offer transport at a lower rate, such a fact must be attributed solely to the rates system now in force on the railways. The motor profits by this system chiefly by working the short distance traffic and, in the case of great distances, choosing the higher classes of goods. In this way motor competition in goods traffic is becoming more and more a danger to the maintenance of the present rates system which is one of the most important foundations of social economy. Their evolution would lead either to a very different evaluation of rail transport rates for the same goods according to the possiblities which exist for transporting these by road, or to a marked levelling up of transport rates for goods of all classes. In both cases it would be impossible to avoid increased costs in the transport of raw materials and bulky products of prime necessity. In the present state of the development of motor traffic a lowering of the rates in certain classes or a general lowering of the rates in certain areas cannot be recommended. In both cases losses in receipts as well as the effects of such measures on the rates system and social economy are even more serious than a perfectly free motor traffic would be. For this reason, at the present there can only be question of rates measures in individual cases, these being exceptions allowed in certain relations or with reference to certain kinds of goods. It goes without saying that such measures should be judged by their financial results. The German Railways in the course of the last few years have introduced a great number of these K rates (rates against motor competition) as their application has given good results. The reductions allowed go up to 25 % and 30 % of the usual rates.

11. — Other causes of motor competition and means of lessening it.

Mr. Sudborough gives no direct reply to the question as to what causes other than failings inherent to the railway and its rates motor transport competition can be attributed, and by what means this could be remedied. However it appears that an indirect and partial answer can be deduced from his statements in No. 5 above, especially his remark that in the United States bus services between States are not under any legislation at the present and that proposals for a law to regulate such enterprises has been laid before Congress.

Messrs. Le Besnerais and Degardin pick out three kinds of reasons all of which have to do with financial considerations, namely : subsidies, taxes and upkeep expenses. It often happens that local public authorities grant subsidies to enterprises which do not give any new and necessary service but compete with railway services already in existence. The constructional and upkeep expenses borne by the railways in France, Spain and other countries, incomparably greater than those which fall upon motor services, have been mentioned in No. 5 above. Messrs. Le Besnerais and Degardin observe that motor competition has only developed in France and Belgium

in an alarming fashion since 1926, *i. e.* since rail transport was heavily taxed in France and, in both France and Belgium, had to impose such rates as would cover all its expenses while a large part of those of the motor services are borne by the whole country.

Mr. Wilkinson in his report gives a very interesting estimate of the causes which have contributed to the development of motoring and facilitated its competition against the British railways. At the end of the great war hauliers were to a great extent subsidised by the opportunity of purchasing very cheaply the great number of motor chassis and lorries returned from the front and also by the possibility of utilising the services of men who had become excellent motor mechanics and drivers during their period of military service. On the other hand, the passenger rates of the railways were raised by 50 % in 1917. The railways were then under Government control and were only handed back to the companies in 1920 in an impoverished condition. By the law of 1921 the English and Scotch railways were amalgamated into four great companies and a very complicated revision of rates and much other business absorbed their attention. Under such conditions, in 1926 the railways were the victim of a general strike which gave a new impetus to road transport. It was only in 1928 that the railways could be said to be free of their problems and in a position to develop their case for application to Parliament for general road powers. Up to that time the railways of Great Britain were not legally entitled to make use of the roads and only certain companies of each railway had limited powers in this respect. The special laws of 1928 gave the four great Railway Companies the right to organise road transport services but with certain restrictions which prevent them from running in certain stipulated areas or in competition with services assured by a local authority in its own area.

Besides these restrictions Mr. Wilkinson gives a list of the obligations imposed upon the railways and analyses the advantages by which motor transport enterprises benefit. The road contractor finds his route already prepared and controlled for him and he is able to extend a service rapidly without much expenditure. He is not a common carrier as railways are obliged to be. He has no restrictions as to the classification of goods or fixed timetable. He is able to run on the roads without stringent limits to the hours of duty of his staff which is not subject to a medical examination.

Besides the means mentioned above (Nos. 9 and 10) the Railway Companies have counterbalanced such advantages by measures taken to extend their traffic by employing practical men as canvassers throughout Great Britain and by the use of many publicity methods. However they recognise that, over and above the development of railway activities, they should also take part in this new method of transport.

The results of the development of road transport upon the railways in Great Britain caused a Royal Commission to be formed to look into the problems due to this development, to point out the measures which should be taken for their better regulation in the interests of the public, and to assist the coordination of their running and development.

Passing on to the other countries (report No. 4) the reporter observes that legislation about regular motor services even in the most advanced countries covered by the report is not yet completed while in many countries it has only reached a preliminary stage.

There has not yet been sufficient recognition of the fundamental ideas that the running of regular motor services can only be considered as a free trade, that in the public interest their impor-

tance necessitates their coordination with other methods of transport, and that competition between themselves or against the railways should be kept within due limits by law.

In countries where the regular motor services are the object of concessions or authorisations, the authorities granting these are usually obliged to take the interests of existing services into consideration. Yet it appears that the regulations in force do not sufficiently prevent the authorisation of regular motor services competing against the railway. In Switzerland legislation actually does make « it possible to avoid sanctioning motor services which would constitute a serious competition to the railways while those that exist form a useful adjunct to the railway system ».

The companies state however that losses occasioned by regular motor services are relatively small when compared with those due to the competition of privately owned cars.

The Swiss Federal Railways give a detailed list (see appendix to report No. 4, question 11), of the profits and advantages resulting to tradesmen and their customers by the direct and rapid carrying out of orders by their own vehicles, as also the benefits of motor transport compared with the charges falling upon the railways, namely: obligation to transport all goods, civil responsibility, fixed hours for staff. stamp duties, construction and upkeep expenses.

The unequal treatment of rail and road services resulting from such legislation must be attributed to the newness of motoring and the consequent lack of regulations imposed upon it. Reform schemes to make good this lack under certain conditions have been marked out by the Administrations. On the occasion of a motion of the Administrative Council of the Swiss Federal Railways intended to protect the Swiss Railways against motor competition, the Federal Council mapped out the way in which it intended to proceed. In the opinion of the Swiss Government it would be necessary to put motor and railway traffic upon more or less the same legal footing. It would be a question not merely of regulating the obligations of the motor services but also of removing certain fundamental obligations by which the railways are bound, such as the obligation to transport all goods and the strict observance of the rates.

Legal defects resulting in unequal treatment of rail and road are also mentioned by Dr. Zietzschmann as one of the chief causes of motor competition. Measures against road competition have as their end not the stifling of motor transport as much as possible, but a new economical division of transport between the two methods. Now such a redivision is not possible as long as rail and road are treated by the law in such different ways. First of all it is essential that motor transport be deprived of the privileges granted it by the law. The motor should bear to the full all those road expenses that it is just to lay upon it. The responsibilities of transport should be the same. Above all it should be exacted that the public expenses of the two methods of transport be equally apportioned. So as to make the concession system of greater use for goods traffic it should be applied to all motor transport enterprises in general and not only to the regular services.

On the other hand the railway which no longer has a monopoly of transport should be allowed to adopt freely such rates as are most suited to its needs, with the reservation that such rates be published and the same for all clients. In exceptional cases of competition special reductions for certain transport enterprises should be allowed.

12. — Regular motor services as additional enterprises.

Mr. Sudborough states that in the United States the railways have now engaged in a very extensive campaign whose object is to combine motor transport with the ordinary train services, and he illustrates this by quoting the programme of the *Pennsylvania Railroad*.

This programme as announced for January 1929 in the matter of *passenger traffic* includes a complete coordination of rail and bus services in the areas served by this company, in some cases the setting up of new bus services and in others by agreement with services already in existence as well as the acquisition of financial interests in such enterprises. The Pennsylvania Railroad Company foresees the organisation of bus services intended to fulfil the functions of local trains on main line sections so as to accelerate the through trains and also to replace the train service on unimportant branch lines completely. Furthemore it is intended to utilise bus services, in a more efficient manner than in the past, as feeders to the railway. The execution of this programme is confided to a subsidary company called the « Pennsylvania General Transit Company ».

In the case of *goods traffic*, the Pennsylvania Railroad took the initiative even before the formation of the above mentioned auxiliary company of making use of motor lorries supplied at first by hauliers, for the mail trains or pick-up goods trains in areas of little traffic, as well as for the carrying of goods between stations at termini. In the pick-up services the lorries go from one station to another collecting parcels and so replace the goods trains for their clients. Up to 31 January 1929 the Pennsylvania Railroad had motorised 5 446 km. (3 384 miles) with slow services, by this means serving 697 stations. In its terminus operations the Pennsylvania Railroad, like many other railways, carries out the transhipment of goods between stations and lines by lorry.

Another example of regular motor services as an addition to the railways in the United States is mentioned by Mr. Bacon (Engineer of the New York, New Haven and Hartford Railroad) in his letter to the Motor Transport World Congress, London session, 1927, an extract from which is quoted in report No. 4.

In their report, Messrs. Le Besnerais and Degardin state that, owing to the advantages motor enterprises are given by the public authorities, the railways have often found that the best way to maintain the struggle was to profit by these advantages themselves and form their own motor services. Such enterprises have been formed either by the railways themselves, as in Belgium and France, or by agreement with private individuals. In France the formation of subsidary transport companies was formally approved by the public authorities and such companies were established by the great companies in 1928. By the beginning of 1929 each company had 5 to 10 regular services of 50 to 150 km. (31 to 93 miles). Messrs. Le Besnerais and Degardin state that these affiliated companies do not seem likely to give brilliant financial results. At the present their services only include passenger and mail transport, as slow goods transport was not realisable by the majority of the affiliated companies. The success of a motor passenger service depends upon its serving a thickly populated town area or else giving a very good service between two towns, a service directly in competition with the railway. Usually the railway companies prefer to modify their train service in such a way as will recover the traffic they are losing. In certain cases when competition shows that the railway is not the best method of transport the solution is

to replace it by a motor service and the French railways have done so in several places with great success. Tourist services must be considered separately; on certain lines, such as the Paris, Lyons and Mediterranean, their present length is 11 000 km. (6 835 miles) and they are usually worked by agreement with private individuals. Certain details about these lines will be found in Mr. Pourcel's paper read at the Motor Transport World Congress, Rome session, 1928, which is summarised in report No. 4.

Up to the present no regular motor services have been organised either directly or indirectly by the Italian railway companies.

In Great Britain bus services instituted by certain railway companies have been running for several years, but it is only since 1928 when the railways obtained general road powers, that the efficacy of these powers has become one of the chief problems to be studied. In the case of passenger traffic, a certain number of feeder services are already functioning. Projects for combined rail and road services as also the substitution of road services for unproductive train services on branch lines are under consideration. It is intended to profit by the very important powers to make agreements with existing road transport enterprises as well as with local authorities concerning services on municipal roads.

In the case of goods traffic the railways are now able to pick up the traffic and carry it by road or rail, which enables them to substitute road transport for part of the way for small quantity traffic, or in certain congested areas, or else to replace the railway services by very flexible routes. The extension of existing lorry services in the country has been mentioned above (No. 9).

The German State Railway Company has organised regular motor services, 11 of which are operated by the Company and 46 of which work in agreement with other enterprises. Good results have been obtained by these services. Direct working gives the best financial results as it does not require the formation of a special company. At the present the German State Railway Company no longer forms regular motor services for itself as it has made an agreement with the Post Office to work such services together. This agreement enables it to exercise its influence on the development of the bus services, the greater part of which belong to the Post Office, and to avoid trouble with the small enterprises which are one of the chief causes of many competitive services.

As for goods transport, the Post Office has given these up to the profit of the railway. The German Railways have organised 43 motor goods services, 14 of them worked directly and 29 in common with other enterprises. Dr. Zietzschmann remarks however that the cooperation of motor goods transport services with the railway is especially advantageous in the case of short distance traffic. A well organised lorry service is able to limit competition. But on the whole the economic possibilities of the use of lorries by the railway are not very great. Competition with the lorries of industrial concerns and commercial houses which must have their own vehicles to keep in close touch with their clients is practically impossible.

Many small cartage enterprises carry out their transports at a minimum rate, sometimes below cost price, counting upon other sources of revenue. The experience of the German Railways has proved it scarcely ever profits the railway to enter into agreements with motor transport enterprises, which will not give up a possible profit without due compensation. For this reason in 1928 the German Railways broke the contract made in 1924 with a motor transport enterprise since it had not answered the hopes of either party.

In the other countries nearly all the railways that replied to the questionnaire have organised the running of regular motor services as subsidiary enterprises and most of them run such services themselves.

The Dutch Railway Companies and the Swiss Federal Railways have entrusted the running of their regular motor services as well as their motor lorry transports and all resulting business to joint stock companies organised as independent companies on capital supplied by the railway companies.

The regular motor services run at the present time as additions to the railway are mostly services joining up with the railways by acting as feeders, but there are some which join places already connected by the railway, by a shorter route, while others are parallel with the rail way and relieve dense traffic or else take the place of originally projected lines. Though in many cases such undertakings are of recent creation so that their results cannot yet be estimated, in the general opinion of the railway companies their results are good and it is intended to develop them.

13. — Mixed services of direct transport.

In the United States tickets for train or bus journeys and through tickets for mixed journeys have been issued or are under consideration. In goods services, the use of motor lorries in conjunction with the railways has made direct transport possible from the consignor to the consignee.

Messrs. Le Besnerais and Degardin observe that as yet, in general, direct mixed transport services only exist after a fragmentary fashion; the French railways and others for example issue at their large stations direct tickets valid for the whole of a journey the end part of which is by bus. The Nord Railway Company carries passengers to the races at Chantilly by taking them to the Nord Station and distributing them over Paris again on return for the price of an ordinary ticket. In the case of goods traffic direct rail and road services are well developed in the special form of porterage and cartage undertakings, however the rates of such services are relatively high and consequently they do not limit motor competition.

In Italy, the State and Emilia Railways have made agreements with certain motor services to issue tickets valid for the whole journey by bus and train.

In Great Britain, proposals for combined rail and road services are under consideration.

In Germany, the establishment of direct rates for railway and Post Office bus service journeys, for passengers and luggage, is included in the newly made contract between the Railways and the Post Office.

The Norwegian and Swedish State Railways and the Swiss Federal Railways have organised direct transport services of goods and luggage and express parcels on certain railway and motor routes. Mixed services of direct transport of passengers and goods have been organised on the railways of the Dutch Indies.

14. — Other means of developing motor traffic as a feeder for railway transport.

One method which promises to be of great use in winning back from the roads much of the goods traffic lost by the railways and at the same time developing motor traffic as a feeder service is the use of metal containers made in such a way that they can be loaded onto both wagons and lorries. These containers carried on motor lorries make it possible to pick up goods at the customer's door and they can then be loaded onto wagons and again unloaded onto the lorries by means of cranes at the station nearest

their destination; by this means all handling of the goods between whiles is avoided. The use of such containers also facilitates transhipment onto boats or onto different gauge railways. This method of transport, which assures door to door services and reduces handling and packing costs as well as losses through damage to goods, is rapidly developing in Great Britain and the United States while it is being tried by the great French Railways and the German Railways.

III. — Summary.

The facts and opinions given above can be summed up as follows :

1. During these last years motor traffic has developed very rapidly in every country, which makes it of great importance as a means of communication.

2. In some countries the extent of the regular motor services, buses or motor lorries equals that of the railways, while in many others it is two or three times as great or even more. Most of these services cover small distances, on the average 20 to 35 km. (12.5 to 22 miles).

3. The proportion of such regular motor services which, because they run between localities already served by the railway or are more or less parallel to the railway, can compete with the railway, depends upon the amount of traffic and the industrial and commercial activity of the population as well as the development of the railway. This proportion is also greatly influenced by the regulations in force for the motor services established in the country.

4. The importance of the traffic of the competitive motor services varies enormously from one country to another. In the United States the kilometric passenger traffic of the competitive motor services is probably as much as 40 % of the railway traffic while in Europe this proportion does not exceed 5 %.

In the case of goods traffic the proportion of competitive traffic is usually much smaller.

The lack of official statistics about motor transport in most countries does not allow of a more exact estimation of this question.

5. In nearly all the countries the running of regular motor services, especially of regular bus services, requires the authorisation of the administrative bodies which, in granting this, take into consideration the necessity for the projected service and the interests of existing communications. Only in a few countries and under special conditions does such an authorisation bear the character of a concession granting a monopoly up to a certain date.

In Germany and Switzerland the Post Office has the right to run regular bus services.

The concession-holders are in general free to choose the routes of the services they wish to run.

Besides State subsidies granted to regular motor services, in certain countries, in regions where communications are insufficient, subsidies are often granted to such enterprises by the local authorities interested.

The revenue from taxes laid upon motors, tyres, petrol, sometimes on the weight of the vehicle and mileage, is usually set aside for road upkeep expenses. But the revenue derived from such taxes, the only share motor transport takes in road expenses, is far from paying for these upkeep expenses and much less for the capital charges incurred in road construction and improvements. On the other hand the railways, in addition to their construction and upkeep expenses, bear very heavy taxes in certain countries.

In most countries the rates of the regular motor services and the maximum

rates, sometimes only the passenger rates, are fixed by the authorities who authorise their running.

In no country is preference in obtaining the concession of regular motor services granted to certain enterprises in at all a general fashion. In two countries the preference is given to the railway if the projected motor service will compete with it. In another country the concession-holders of regular motor services are given the preference when it is a question of granting a concession for adjacent lines.

6. The rates of the regular motor services vary much from one country to another. The passenger rates usually more or less equal 2nd class railway fares, but in certain countries they are as much as 60 % higher, and in others lower than railway fares. The goods rates are also determined by those of the railway, and for short distances are usually lower, though in some countries they are several times as much.

7. It is very difficult to estimate the losses in railway traffic in different countries, which can be directly attributed to the development of motor traffic, because it is practically impossible to eliminate other factors which might have had an influence on such losses, as well as to judge the profits which the railways may have derived from motor traffic in its feeder capacity. In most cases the lack of statistics relating to motor transport complicates the problem. To evaluate such losses in traffic, recourse has to be had to the estimation of the losses in receipts with more or less probable corrections.

An appreciation of the effect of the competition of regular motor services upon the traffic of the railway which will set aside the effects of other motor transport methods is still more difficult. According to all the information received when transports are lost by the railways, it is mostly due to irregular services and to the cars and lorries of private individuals.

In the passenger as well as the goods motor services, competition is greatest in short distance traffic and decreases inversely with the distance. For this reason the losses of the great railway companies are comparatively less than those of local railways or branch lines.

In passenger services the total loss in the receipts of all the main railways of the United States in 1927 was estimated as 24 %, while the losses of certain of the great companies was not more than 7 %. The losses of the European railways are usually much less, but there is a very marked difference between the different companies, depending upon their traffic.

In 1928 the passenger traffic losses of the German railways due to motor competition were valued at 10 % of the receipts, 1/5 of which — i. e. 2 % — was attributed to regular bus services.

In the case of goods services, the losses of several of the European railway companies due to motor competition have been estimated at from 6 to 10 % of their receipts. The competition of regular motor services seems to have still less importance for goods traffic when compared with the competition of irregular services and privately owned motors, than for passenger traffic.

8. The estimation of the effects of motor competition on railway traffic differs in Europe and America.

Mr. Sudborough's opinion is that if the passenger traffic of the United States railways has diminished during the last few years, these railways have at the same time been called upon to transport a continually increasing amount of goods traffic, and the remarkable expansion of the motor industry has been one of the chief factors in this increase. For this reason the United States railways have really gained by the creation and development of the motor industry.

The European railways are very far from estimating motor transport as favo-

rable to the development of their traffic, but pity themselves for having to put up with such losses. Dr. Zietzschmann states that the German railways specifically deny that they obtain any direct profit from transports resulting from the motor industry and quotes their reasons.

9. The improvements in rail transport undertaken by the railways to combat motor competition are very numerous.

In the case of passenger traffic efforts have been made above all to improve the timetables and to give passengers greater comfort and increased travelling facilities. A faster train service which is further increased by the organisation locally of light and frequent trains consisting of rail motor coaches and rail omnibuses, as well as through trains on branch lines, 3rd class sleeping cars and upholstered seats in 3rd class carriages, luggage in advance facilities and rapid transport by motor vehiles at reduced rates, etc., have all been tried. Certain crowded lines have been electrified.

Messrs. Le Besnerais and Degardin remark that in spite of all these improvements rail transport will always have certain failings which it would be too difficult or expensive to correct. For this reason efforts should be made towards a close collaboration between railway and road services, leaving to the latter services where passengers are not very numerous, sometimes by the closing of the railway service. Such an idea would seem to be perfectly fair, provided that the railways themselves were able to arrange such collaboration in their own as well as the public interest.

In the case of goods traffic, efforts have chiefly been directed towards the speeding up of transport, the simplification of consigning and the realisation of door to door transport. Since motor competition is chiefly felt in the case of express goods and small transports, delays in transport have been reduced by speeding up the trains and shortening the halts at stations; more frequent and quicker long distance services with delivery on the following day have been organised between the industrial centres; the times at which offices remain open has been extended and night work introduced in the goods yards of important stations; private depots for clients have been formed; a cartage service has been organised and this is usually run by the railway itself.

Many rates measures intended to lessen motor competition have been enforced especially in the case of short journeys and return journeys, group journeys, week ends, Sunday travelling and in the case of certain kinds of tickets : season, family, excursion, workmen tickets and tickets to watering places; the validity of tickets has been extended; the journey can be broken; the age limit for children has been raised, etc...

Transport rates are of more importance in the case of goods than of passenger traffic; for this reason the lowering of the goods rates is the best way to combat motor competition. There have been reductions in the goods rates on nearly every railway in many cases, especially for short distances up to 100 km. (62 miles), for certain services or certain kinds of goods. Such reductions together with new consignment and transport facilities depending upon their financial results, in many cases have won back traffic to the railway.

In some countries (Denmark, Holland, Switzerland and Czechoslovakia) railway companies have been allowed to make agrements with their clients as to transport rates in certain cases.

It has been necessary to make such exceptions to the rates charged at the present time, as a general reduction in certain areas or for certain kinds of goods would result in losses in receipts and would have a dangerous effect on social economy. It can be foreseen that the development of motor transport with rates

based on different principles than those of the railway will increase the number of cases in which exceptional reductions of railway rates will be necessary and thus lead to a fixing of transport rates to the detriment of the transport of such goods as are of prime necessity and of but little value.

11. Other causes of motor transport competition, besides the technical and rating defects of the railways, can be arranged in two catagories : on one side stands the want of legislation binding motor transport and the privileges by which it profits; on the other the expenses and obligations of the railway.

An economical distribution of transport between the two methods of communication should be the basis of any legislation concerning them. Motor transport enterprises are not obliged to transport, nor to treat all their clients alike, nor to keep strictly to any rates; they have practically no civil responsibilities, nor limitations set to the hours of their employees; they only bear a small proportion of road expenses and in some countries even benefit by subsidies from the State or Communes. On the other hand the railways, who have all the obligations enumerated above and bear all their construction and upkeep expenses, are often subject to heavy taxes and other expenses.

This unequal treatment of motor and railway enterprises is one of the chief causes of motor competition, a cause which should be attributed to the newness of motoring and the consequent lack of any legislation relating to it.

Projects of legal reform with the object of regulating the obligations of motor services as well as the mitigation of certain fundamental railway obligations have been mentioned by several Governments.

12. The technical and economic advantages of motor transport : rapid organisation of a service with but little capital expenditure, operation by small units running frequently and rapidly, door to door services, are often indisputable. A collaboration between this method of transport and the railways, the best method of transporting great numbers of passengers and heavy goods, would seem to be indicated.

But at the present, legislation concerning motor transport enterprises renders collaboration with them very difficult by placing them in a privileged position as regards the railways and thereby opposing the interests of these two means of communication. The situation being such, the railways have considered the creation and conjunction of motor enterprises to their own train services, so as to profit themselves by the advantages of this method of transport.

Such a programme is planned on a large scale and energetically carried out in the United States; it is also followed in Great Britain and other countries. Many railway companies have organised motor services which act as feeders to them or join, by a shorter route, places already joined by the railway or are parallel to the railway in order to relieve congestion, or to take the place of an originally projected railway. Such services are usually run directly by the railway as a subsidiary enterprise or else by an affiliated company on its behalf, or sometimes by private individuals by agreement with the railway. The German State Railway Company has made an agreement with the Post Office which runs nearly all the bus services in Germany. The direct working of motor services by the railway seems to be the best solution as long as it does not require a special department.

Several railway companies (Pennsylvania Railroad — New York, New Haven and Hartford Railroad — Great French Railways — Dutch Railways) have given the companies organised by them with their own capital, charge not only of their

motor services but also of their cartage services and also all business in connection with the relations between rail and road and motor competition. Such companies are developing and giving good results.

13. The organisation of mixed rail and bus services in the case of passenger traffic with a possible choice of route is in process of being realised on several railways in the United States and the Dutch Indies, while it is being considered by several European railways for certain journeys.

In the case of goods traffic, a complete through mixed service of door to door transport which is one of the chief advantages of motor transport, is being more and more extended.

14. Among other means of developing motoring as a feeder to the railway is the use of containers made in such a way that they can be loaded onto both wagons and lorries, and so enable the packing and handling of goods to be avoided. They are being used more and more all over Great Britain and the United States and are being tried on the Great French Railways and in Germany, and would seem to be an efficacious way of combating motor competition in the case of small transports.

* * *

The reporters are practically unanimous in their conclusions. These may be summed up as follows :

Railway interests as well as public interest demands a close collaboration between railway and road. In order to assure the best technical and economical results such collaboration must be duly coordinated and this is not possible with the present state of legislation relating to motor transport and the legal expenses and obligations which are incumbent upon the railways. This state of affairs is the chief cause of unfair motor transport competition and its harmful effects on the whole country.

While the present state of motor transport conditions lasts, apart from certain technical improvements in their transport services, the only measures that the railways can take against this unfair competition which is ruining them, is the power to grant exceptional rates or to make special agreements in the cases of goods services, where there is comptition, to the detriment of the other rates, or else to profit by the advantages granted to road transport by organising motor services themselves.

The railways of Great Britain and the United States appear to consider this last measure of capital importance while in other countries attention is chiefly directed towards the technical improvement of transport and towards rates measures, though in certain cases the organisation of motor services as subsidiary enterprises is not neglected.

IV. — Final conclusions.

1. Because of the growing importance of motor road transport and its competition with railway transport, the common interest of both methods of transport, as also public interest, requires an exact appreciation of their respective values as regards communication as a whole and the coordination of their services.

To attain such an end, the present legislation relating to motor transport, which in most countries gives it the advantage over the railway, must be modified in such a way that motor transport may bear its full share of road expenses, and the public expenses of both methods of transport should be equally divided.

2. The system of free competition allowed in some countries, or the purely formal authorisation of regular motor services without regard to existing communica-

tions and without sufficient guarantee of the civil responsibility of the concession-holders, is not at all in the interest of the public.

The concession of regular motor services competing against the railway or other communications already in existence which do not give the public any new advantages should be prohibited. Before granting a concession to any regular motor service, the authorities who have the right to do so should be obliged to consult the railway companies of the district about it.

3. The indisputable advantages of motor transport, such as direct door to door services, operation by small units running frequently and rapidly, immediate organisation of a service with but little capital expenditure, are a valuable adjunct to the railway in many cases — services between stations, small and new traffic, tourist services, etc., — and everything points to the advantage of collaboration between it and the railway which is the best transport method for a great number of passengers and heavy goods.

To assure as far as possible a close collaboration between motor transport and the railways for transport as a whole, the railways should have the preference for obtaining the concession of regular motor services and profit by it.

4. Motor transport competition is especially found in short distance traffic [up to 50 and 100 km. (31 and 62 miles)] and lessens railway traffic to an extent that depends upon the importance of the motor service, legislation concerning it and other local circumstances; in the case of passenger traffic the losses are as much as 24 % of the receipts of the main lines and as much as 60 % for lines of local interest, and in the case of goods traffic as much as 10 %.

These figures include the losses due to the competition of irregular enterprises as well as cars and lorries owned by private individuals, which, in certain countries where motor traffic is highly developed, are much more important (four times as much in Germany) than the losses due to the competition of regular motor services.

5. The passenger fares of regular motor services are usually like those of 2nd class railway tickets, but in certain countries as much as 60 % higher, in others lower.

Goods rates also are regulated by the railway rates and for short distances are usually lower, but in some countries they are several times as high.

Such differences in rates testify that motor transport competition, especially in the case of passenger traffic, must be attributed to other advantages than its economic results.

6. To diminish motor competition the following improvements in rail transport have been carried out with good results :

a) Passenger traffic :

Organisation of local services of light and frequent trains formed of rail motor coaches and rail motor omnibuses on lines where traffic is small, with provision for frequent stops between stations; organisation of through services on branch lines; organisation of cheap excursion trains on holidays; improvement of train connections at junctions and various timetable improvements; 3rd class sleeping cars and upholstered seats; luggage in advance, etc.;

b) goods traffic :

Speeding up of transport by means of direct services and complete loads, attached in certain cases to passenger trains; reduction of time spent on the journey and halts at stations; reforms in consigning of goods, especially in the case of parcels so as to facilitate their collection and delivery and the speeding up of their transport; more prompt forwarding of goods from transhipment

stations; organisation of private depots for clients, etc.

7. Road arrangements to assure a complete door to door service for clients have been completed on certain railways under the form of motor and motor lorry services organised by the railway company itself or by means of agreements with private enterprises.

8. The use of containers which can be loaded onto both wagons and motor lorries is increasing rapidly on some railways and facilitates direct transport for small traffic.

9. A great many railway companies have organised or are organising regular motor services as subsidiary undertakings which are to act as feeder services or to run parallel with their own lines to relieve local congestion. Some of these railway companies (Pennsylvania Railroad — Great French Companies — Dutch Railway Companies — Swiss Federal Railways) have confided the running of their regular motor services as well as the cartage services and all business resulting therefrom to companies organised as independent undertakings on capital provided by the railway. According to the information received these two types of subsidiary undertaking give promise of excellent results in the matter of the collaboration of road and rail.

10. Mixed services of direct transport by railway and regular motor services belonging to the railway as well as other enterprises with possible choice of route have been organised by several railway companies in the United States as well as in certain cases in Europe. Such services seem likely to develop.

11. Many reductions in passenger and goods rates have been made by all the railway companies, especially in the case of short distance traffic up to 100 km. (62 miles) in certain cases, or for certain kinds of goods where there is competition.

The unequal conditions in which the railways stand as compared with motor transport in the matter of the obligation to transport and strict adherence to rates has obliged several Governments (Denmark, Holland, Switzerland, Czechoslovakia) to allow special agreements to be made between the railway and its clients for the permanent transport of fixed quantities of goods at reduced rates. This measure, applied on condition that the rates decided upon correspond to the reasonable cost of transport by motor lorry and assure the railway a profit compared with cost price, has proved efficacious.

12. Motor road transport has taken from the railways the monopoly of assuring rapid and economical communication between one place and another. The legislation concerning the railways, in force at present in different countries, does not take into consideration the great change which has taken place regarding them. It is to be hoped that these legal failings, one of the chief causes why road competition is often unfair, will be made good and that the use of a less stringent rating system on the railway will contribute to placing road and rail transport upon an equal footing. By this means their close collaboration for the public good will be made possible.

13. The information received from the railway companies themselves and other documents prove that motor road transport competition which has increased very much on certain railways by reason of local circumstances, has been sufficiently diminished by other companies by the speeding up and improving of railway transport, by the organisation of regular motor services as a subsidiary undertaking and by mixed services of direct transport as well as by other technical and rates measures of the rail-

way companies supported by Governmental legislative measures.

Projects of legal reform with the object of regulating the obligations and expenses of the motor services and the lessening of certain fundamental railway obligations have been promised by several Governments.

These examples make possible the hope that motor road transport duly coordinated will become a powerful ally of the railway and assist in completing and developing communications to the greater profit of the public.

The Railway Companies and the Congress should be warmly recommended to study this problem further in order to attain such an end.

QUESTION XIV.

(USE IN RAILWAY WORK OF MACHINES FOR SIMPLIFYING STATISTICAL AND ACCOUNTANCY WORK) (1),

By Dr.-Ing. TECKLENBURG,

Special Reporter.

Question XIV concerning the use of mechanical auxiliaries for accounting and statistics by railway Administrations, has been answered in three separate reports submitted by :

Mr. William E. Eppler, for America, Great Britain, China and Japan (2);

Messrs. Bruneau and Boistel d'Welles, for all other countries, with the exception of those mentioned above and Germany (3), and

Messrs. Drs.-Ing. Tecklenburg and Gaier for the German State Railway Company (Reichsbahn) (4).

All three reports follow the same lines of thought and show agreement on all main points.

A separate discussion on the three reports individually would entail a large amount of unnecessary repetition. It appears therefore that a joint exposition, in which the views expressed by the individual reporters on the various outstanding questions are quoted, would best meet the case.

A. — General viewpoints on the application of machines.

The introduction of machines and mechanical auxiliaries for office work has for object the carrying out of accounting and statistical work more economically.

In this report only a few of the questions from the wide area covered by measures for rationalization are dealt with. This question is of very great importance to the railway administrations, because of the huge mass of accounting and statistical work which has to be carried out in their offices. While in earlier times, the railway authorities were driven to introduce such apparatus as typewriters and calculating machines simultaneously with their adoption by business circles, the development in this direction has only of late years become specially active as a result of the universal effort which is everywhere being made in business circles for rationalization.

The furtherance of economy in working methods is not altogether synonymous with the introduction of machines. Messrs. Bruneau and Boistel d'Welles remark, in this connection, that very often substantial savings are attainable by means of pure and simple rationalization and that these savings are among those which can be obtained by mechanization, that consequently before the introduction of mechanical measures, it should be decided how far such results can be got by those other methods (pure and simple rationalization). Both gentlemen emphasize the fact, that the creation of a special organization is imperative to carry out satisfactorily the

(1) Translated from the German.

(2) See *Bulletin of the Railway Congress*, May 1929 number, p. 507.

(3) See *Bulletin of the Railway Congress*, November 1929 number, p. 2499.

(4) See *Bulletin of the Railway Congress*, March 1930 number, p. 951.

investigations concerning the measures for rationalizing and mechanizing accounting and statistical operations, and that this organization should be competent to act as an adviser to the various offices on all questions which might come up. They quote several administrations (the Dutch Railways, the Paris-Orleans Railway Company, the French State Railways) who have created such an organization. The similarity of the questions arising, their frequent interconnection, the basic knowledge of the continual development of the mechanical auxiliaries used, which is learned in the course of work, have convinced them that administrations would gain real and important advantages from such an institution.

The Reichsbahn (German State Railway Company) has likewise set up such an institution; it has also a central department, the Railway Central Office, in Berlin, which is entrusted with the duty of examining in an uniform manner the basic questions of mechanizing and rationalizing office work, and as a result of their accumulated knowledge, of assisting the various offices in regard to all questions that may arise. A very valuable basis is provided by the work and time studies, for undertaking which, the Reichsbahn has laid down special lines; the same has been done in the case of the operating, the traffic and the workshop services and also for the office service.

As a rule rationalization is arrived at by organizing methods coupled with mechanization. The common axiom in this connection is : That the introduction of machines is economically justifiable, if, after taking into consideration purchase cost and depreciation due to their becoming rapidly obsolete, or if because of their use, by increased speed, or improved work, savings are made in proportion to the expenditure incurred.

These indirect advantages are accorded a special and indeed decisive importance in all three reports. Messrs. Bruneau and Boistel d'Welles in this connection state as follows : « The main object for the improvement of accounting and statistical work is reduction in cost but other considerations such as extending the possibilities of investigation, delay in completion, doubt as to accuracy, may justify alteration of the system. »

Mr. Eppler follows the same line of thought, in that he says : « Profit and economy provide the leading reasons for the use of machines to simplify statistical and accounting work. » He goes on to say that the savings produced by the use of machines for simplification of statistical and accounting work, are soon apparent definitely and demonstrably, although hidden, hard to appreciate, and difficult or nearly impossible of proof, through being so small, though this last condition does not in itself necessarily constitute a ground for criticism. The alleviation of the nerve destroying sameness of office work is often considered as a justification for the introduction of machines. When discussing individual machines, all three reports place the machines for statistical purposes, that is to say the so-called punched card machines, in special prominence; from this it can be gathered with what importance this type of machine is regarded by the administrations who have installed it. This is quite understandable, because all other office machines aim at the alteration of only a single operation, while the machines dealing with statistics postulate a vast change of the research organization which is of the greatest importance for the areas of research concerned. In another way the results are also of very much greater importance, so that one might without exaggeration ascribe to the introduction of machines for statistical purposes, a far reaching change in the collection and possibilities of appraising statistics.

In the following discussions, the perforated card system and the questions relating to it must first be taken in detail and the rest of the machines and apparatus will then be dealt with.

B. — Machines for statistical purposes (perforated card machines).

1. The machine system.

In a short historical retrospect, Mr. Eppler indicates the importance of statistics by a number of examples from history by which he points to the beginnings of more than 3 000 years ago, such as the census in ancient Egypt, and of the children of Israel, the institution of tax assessment by Solon, and the registration of births and deaths in the temples of ancient Rome, then brings out the increase of importance of statistics with the lapse of time and leads up to the invention of machines for statistical purposes by the American Dr. Hermann Hollerith. These machines were first introduced with excellent results by the American Government in the year 1890. A railroad administration, the New York Central Railroad, was the first commercial user, as it installed a number of these machines in the year 1896.

The basic idea underlying all machines for statistical purposes is that all matter that has to be statistically collected is expressed in figures, these figures are punched on a card, sorted in a machine and then tabulated in another machine. This basic idea is the same for all machine systems, in the Hollerith machines, the Powers machines and the Madas machines, mentioned in the reports of Messrs. Bruneau and Boistel d'Welles. The differences in the systems lie mainly in the method of operating : the Hollerith machines are operated electrically, while the Powers are electro-mechanical.

The constructional characteristics and the design of the machines are thoroughly explained in the reports of Messrs. Eppler and Bruneau and Boistel d'Welles; it is not therefore necessary to describe them again here; it may nevertheless be of interest to comment on some of the special attachments and improvements which have been introduced during the course of the last few years.

The four units with which the statistical machines operate are :

The perforated cards.
The card punching machine.
The sorting machine.
The tabulating machine.

a) *Perforated cards.* — The form and division of the cards can be taken as known. It is worthy of note that Hollerith has introduced 60 and 80-column cards in place of those with 34 and 45 columns. The difference lies in the increase from 34 to 60 columns and from 45 to 80 columns; the form of the cards remains the same. A square punching is proposed in place of a circular one.

b) *Punching machines.* — In addition to magnetic punchers, hand punchers and duplicating punchers, Hollerith has lately introduced a magnetic punch with automatic feed and delivery. Attention is called to the Powers hand puncher with decimal tabulator, and the key and alphabet puncher. Certain punching machines of both makes can be coupled with typewriting, adding and calculating machines.

Both makers also provide :

Verifying key punchers. — The Powers control machine is worthy of note, as having the advantage that its 12 plungers cover all the colums of the perforated card. Should there be a wrong hole or holes or other error in any column, the carriage remains stationary at the column concerned, the machine is locked and the incorrect

card is automatically ejected into a special compartment.

c) *Sorting machines.* — In addition to the 45-column sorting machine, Hollerith also markets an 80-column machine. Mention may here be made of the following attachments to the Hollerith and Powers sorting machines : Card counter and verifyer; in addition, the Hollerith debit and credit selection device, and the Power's verifying device. Hollerith has lately introduced the card counter on a special counter bank, which prints off the results of the count.

d) *Tabulating machines.* — The machines of both makes, the constructional details, and the methods of working which have been taken as well known, are today offered with a number of supplementary attachments of which only the accounting device and the automatic paper feed device need be mentioned. In the Powers type of machine, letter printing mechanism can be substituted for the totalizer mechanism so that any text desired can be written.

The Reichsbahn lays stress in its report on the fact that it sees the great advantages of these machines not alone in the possibilities of producing statistical collections more quickly, more cheaply and with less cost for labour, but, and on this it lays considerable weight, that by the utilization of the possibilites inherent to the system a means is offered of obtaining a very much better insight into progress of operations. Researches which, if made by purely manual means, would prove so costly in time or labour, that they could not be economically considered, are brought to realization entirely by means of the perforated card system, and areas which would otherwise remain in darkness are, by this system, laid open to inspection.

Of course it must not be overlooked that a certain danger exists in that the advantages of the system can tend to lead to statistics being elevated into a position in excess of actual requirements. Before a new statistic is introduced or an existing one is extended, it must, therefore, be established beyond doubt, if such statistic is actually required and if the advantages arising from it are worth the cost entailed.

Mr. Eppler says that the machines appear very well adapted to draw out dormant energy, the realization of which increases the output of work. One must nevertheless estimate the value of the results attained in statistics and calculations, more in accordance with their value than with their numbers. The deciding factor must be the results in the statistics and calculations and not simply the number of statistics which are made possible by the use of mechanical auxiliaries.

To settle the question as to whether the introduction of machines will be economically of advantage to the railway administration, it is necessary to weigh the expected advantages against the increased cost, and for this a conclusive opinion is necessary on the costs of the system.

The report of Messrs. Bruneau and Boistel d'Welles deals on this account very closely with the question of cost. Purchase of cards will cost 33 fr. and the monthly hire of a Hollerith tabulating machine with 5 counters and all the latest improvements is 6 to 7 000 fr. If it is accepted that a machine will be worked for 200 hours per month, one hour's work with the sorting machine, including 15 fr. for staff and one hour's work with the tabulating machine, will cost 37 fr. It is clear from this that the advantage which the machines offer, depends substantially on the number of passes made by each card through the sorting and tabulating machines and from the results which can at the same time be totalled from each tabulation, as well as on the average number of figures in each result to be added. The report shows by figures that when only sorting is concerned, the monetary ad-

vantage of machine work will be very small as compared with hand work, and it comes to the conclusion that the real money saving part of the work is the tabulation. The savings there are dependent on the number of the accounts to be added; on the basis of the settled prices for adding machines and wages, the result is that in the case of 4 tabulations nothing is gained above the recovery of the price for punching. In like manner the gain by using the statistical machines to replace multiplication and addition machines is calculated. When for instance it is desired to multiply one row of figures with coefficients which consist of a maximum of three figures, the use of statistical machines only appears advantageous if more than 3 multiplicands are to be used.

The Reichsbahn also puts great importance on the cost question : it states in its report that it has regulated the extracting of the cost of the perforated card method of working by a special service instruction and in the sense that the cost of each investigation shall be accurately determined. By this means not only is information obtained on the actual cost of the perforated card system, but in the course of these researches, a helpful means is obtained of checking the working organization of the various perforated card offices.

Supplementing this discussion, it may be of interest to give below some results of the cost investigation.

For each 1 000 cards the total charges from all sources are :

Cost of cards	5.90 Rm.
Cost of punching	11.52 »
Cost of checking	10.76 »
Cost of sorting	4.08 »
Cost of tabulating	8.35 »
Other cost (office-calculating work, and management cost)	7.73 »
	48.34 Rm.

The three reports give exhaustive information on the subject of the use of the machines by the various railway administrations.

According to the report of Mr. Eppler the machines have found extended employment in America; in the United States they are in use on numerous lines, and the same is the case in the Argentine, Brazil, Chile, Cuba and Mexico, in Great Britain and its Dominions and Colonies. Mr. Eppler mentions also Japan, and states that the South Manchuria Railways have instituted enquiries and have undertaken tests to adapt machines to their requirements. In the case of the administrations dealt with in the report of Messrs. Bruneau and Boistel d'Welles, on the other hand, the machines do not seem to be yet in general use : of the 90 administrations out of the 147 who have given answers to the questionnaire, only 11 appear as users of statistical machines. Among these, the Dutch Railways, the French State Railways, the French Nord Railway, the Paris-Lyons-Mediterranean Railway, the Norwegian State Railways, the Checho-slovakian State Railways, the Swiss Federal Railways, the Paris-Orleans Railway and the Belgian Railways, appear.

In Germany again, as is stated in the report, the machines are widely used at the present moment 79 tabulating machines and 87 sorting machines are in use, divided over 72 working offices and, with 1 300 punching machines, handle a yearly total of about 90 million cards. An increase in their number is to be expected when the tests in connection with a number of other research areas which are now under way, are concluded.

The areas of research in which the statistical machines find employment, are very numerous.

Mr. Eppler brings to notice the extraordinarily manysided applications possible for their employment by the Delaware and Hudson Railway Company,

which, as a progressive Railway Company in the United States, makes extended use of these machines for calculating and statistical work. Machines are being used by that Company, or their use is in prospect, for the following operations :

Recording the hours worked (operating service, section and train service) and preparing the necessary pay sheets in connection therewith.

Division of the wages cost on account of working expenses and other accounts.

Preparing the work-statistics concerning :

Wages, division of the personel, insurance in groups, etc.

Preparation of invoices to be sent to other railways for repairs to their rolling stock.

Preparation of statistics concerning goods, amount of tonnage and traffic.

Establishing goods receipts, interchange and through traffic.

Getting up statistics concerning protests about too high charges and concerning losses and damages.

Getting up statistics of locomotive operation, wagon working, rolling stock and amount of tonnage.

In an appendix to his report Mr. Eppler describes the usual practice of the Delaware and Hudson Company for working out wage hours.

Messrs. Bruneau and Boistel d'Welles are of the opinion that the most paying possibilities for application are provided by the train operation enquiries, as these embrace a large number of separate details : Section kilometres, tonne-kilometres according to description of train, type of locomotive, kilometres run by driver and locomotive, this last entry as a basis for the calculation of running premia. The report mentions as Administrations which use the perforated card system for this work in particular : the Belgian, the Dutch Railways, the Swiss Federal Railways, the Paris-Lyons and Mediterranean Company, the Paris-Orleans Company. The Reichsbahn who uses the system in this connection, quotes the special advantages which it derives from the change over to the perforated card system of its operation output research as it is made possible to set up a section loading card, which brings into view the loading of all sections of the Reichsbahn network. Further the Reichsbahn emphasizes the fact that, by means of the proper organization of the operation efficiency research, it is put in a position to be able to put up in a short time, that is to say within a week of the expiry of the period covered by the investigations, a complete review of the whole operations over the whole system, as well as those of the individual districts. This operation research statement, following as it does almost on the heels of the actual happenings, gives a mirror-like reflection of the seasonal variations of traffic and provides a means of accomodating the working arrangements to the demands of the traffic.

A very much wider sphere of application lies in the calculations concerning the hire of rolling stock. Messrs. Bruneau and Boistel d'Welles here mention the Dutch Railways, the Czechoslovakian and Belgian Lines as well as the French lines, the latter operating through the medium of the Clearing House for the French systems. The Reichsbahn operates in exactly the same way as the Railways named above, as is more fully described in the report.

A specially important and spacious area is provided by traffic accounting and traffic statistics. The Clearing House control of the French systems, according to Messrs. Bruneau and Boistel d'Welles, uses for this purpose 1 million 500 000 cards per month, and employs 50 punching machines, 10 sorting machines and 5 tabulating machines. The Dutch Railways, and those of Czechoslovakia and Norway are also mentioned. The system worked in these cases is

naturally dependent on the special requirements of the railway administrations and the demands which these impose on the statistics.

The Deutsche Reichsbahn mentions in its report that it uses the system largely for researches which are not of a regular nature, but which are made periodically and from time to time; examples are : counts of passengers in trains, wagon movement research, duration of service statistics, etc., and in, a different direction, for the accidents in working statistics. In this case the chief value of the perforated card system method lies in the fact that the cards which are made out for each accident and contain full details which may be required to form a judgment on such individual cases as may come under review, are attached to a file and are thus permanently available for future reference.

It is readily understood that this description of the various applications is not complete. Where the system has once been introduced and the machines purchased, an extraordinarily large number of opportunities are offered for its useful application; the German report mentions an additional list of possible applications and the same is true in regard to the other administrations, as may be gathered from the report of Messrs. Bruneau and Boistel d'Welles.

It would occupy far too much time to go into details.

It can only be recorded there is every prospect, with a wider introduction of the system, that very advantageous possibilities will be provided for its application for international collaboration, especially in the direction of reciprocal accounts and in connection with international traffic.

3. The results of the mechanical system.

A few administrations have provided information as to actual savings made by the change over to the mechanical system, as apart from the increased speed and improved accuracy gained. The Paris-Orleans Railway Company, who deals with 110 000 cards per month in the course of its operation output research has been able to reduce the staff from 96 to 66, with a yearly saving of about 400 000 fr. The Belgian Railways who deal with 130 000 cards per month in their investigations state that they reduced the staff by about 84 officials representing a clear saving of 1 million fr. A substantial portion of this saving however, add Messrs. Bruneau and Boistel d'Welles in their report, may be due to centralization of the work. The Dutch Railways give a clear saving of 25 000 florins.

The Czechoslovakian Railways have, according to Messrs. Bruneau and Boistel d'Welles' report, effected a saving in personel of about 64 (20 of these from « through » stations) in their wagon hire department on balance accounts, and the Wagon Office of the French systems has made a similar reduction of 20 units representing a saving of 300 000 fr. The Reichsbahn says in its report that where it formerly had a staff of 141 in the wagon hire balance accounts branch, it has since the change over to the mechanical system only 90; if the cost of the machines is converted into the equivalent in work power it would represent 26 persons and there remains an actual saving of 25 persons.

The savings actually made and the indirect advantages to be gained by bringing individual activities under machine operation, can be so important that the Reichsbahn thinks that the greatest advantages are to be seen in the possibilities of extending and speeding up statistical researches. This has, as the report of the Reichsbahn shows, assisted to confirm it in the intention to make the dead statistics alive, so that they shall be a reflection immediately follow-

ing upon the actual occurrences, and thus to be valued as bringing profit to the undertaking.

Keeping this point of view before it, the Reichsbahn has placed the greatest value on the production of an all-embracing operation statistic, and in this sense, that the output of work done in kind and quantity, and characteristic of the work of each department, should be recorded for each branch. Such a comprehensive operation statistic would — at least in the case of the largest and most important classes of output — only be made possible by means of the perforated card system. The Reichsbahn has broadened out these operation statistics into an economic statistic, continually dealing with the whole undertaking which, coupled with a similar one dealing with the expenditure side, has been built up into a working cost account. In these economic statistics, which show the internal interconnections of the business, which make clear the economic importance of the part in the fabric of the whole structure and which are designed to bring the internal economy of the undertaking under a close and permanent scrutiny, the Reichsbahn believes that it has created auxiliary means, which are of very great importance in connection with the efforts for the general rationalization, which it has been aiming at for years.

At the same time the Reichsbahn has obtained the basis for the solution of an old railway scientific problem, the problem of an ascertainment of the working cost of the railway undertaking. A working cost account built up on this basis has for some years been regularly got out by the Reichsbahn.

c) *Other machines.* — The reports contain a large amount of information on the subject of the machines and apparatus which are being brought into use by railway administrations. It is understandable that the railways should endeavour to make use of such new arrangements as offer to the business world. The introduction of such apparatus however naturally remains dependent on its providing economic advantages.

On this subject Messrs. Bruneau and Boistel d'Welles point out with emphasis that, in all economy accounts, the number of the officials replaced, the amounts of the costs for the purchase of the machines and their amortization must be balanced one against the other. Taking for example, the working of an adding machine with printing attachments for letters and figures, the purchase cost of which is 60 000 fr. and the maintenance and amortization charges for which will be 15 000 fr. per annum, will only be of advantage when more than one person can be dispensed with; practically it will only be profitable when two persons have been saved. These considerations have undoubtedly their reactions on the extent of the actual introduction of machines. Messrs. Bruneau and Boistel d'Welles who, in their report, deal with the desirability of the employment of machines in the various offices confirm that the mechanization of the great railway stations may only, as a general rule, be carried out to a restricted extent; they base this on a variety of circumstances. First the irregularity of the calculating work in the station offices during the day, which leads inevitably to an excess of personal during the slack hours; the frequent change in the female personnel of the stations and the necessity of instructing the new employees tend to discourage other systems from following this path. From a general point of view, the small size of many of the offices to be organized makes the mechanization of calculating work difficult. Small and medium sized stations do not therefore come into the question. These different considerations lead to the conclusion that central stations should be selected, at which the calculat-

ing work for a whole district might be carried out, but which need not be actually carried on in the station itself and where a specially large office could be arranged for the mechanization. The Swiss appear — from their somewhat summary declaration — to have leanings in this direction, in that the account book of each station is brought each day to the head office.

It is indisputable that concentration in one place simplifies supervision and operation and makes combined use of the machines possible.

Based on these considerations Messrs. Bruneau and Boistel d'Welles come to the conclusion that the collection of similar work from a definite area, the various local service branches belonging to a great district (vertical concentration), is generally bound up with mechanization, and is in fact almost to be considered as a preliminary condition.

What is stated in the three reports concerning office machines and other apparatus is extraordinarily manysided and comprehensive. Of the office machines, it is in the first place the typewriters and calculating machines with their numerous special attachments, which are specially dealt with in the reports of Mr. Eppler and the Reichsbahn.

Besides these, Mr. Eppler deals with a large amount of other apparatus, including duplicating apparatus in its various forms, also letter openers, numbering machines, dating machines with clockwork movement, signographs and cheque protectors. Among special apparatus for the equipment of large business premises are postal tube installations, self acting electric lifts for letters, shoots for letters, and various accessories for the dispatch of letters; the German report deals with a similar installation in the shape of the express post for documents and an annunciator for visitors.

It is not possible to deal with all these arrangements within the limits of this combined report and reference must therefore be made to the individual reports. The following descriptions will therefore be confined to the most important machines and the descriptions in the three reports will be briefly repeated.

Typewriters.

When discussing the typewriters, which are used in the widest way in the offices at headquarters, divisions and in the numerous sub-offices, the report of the Reichsbahn points to the standardization of the most important parts of the machine and its accessories, and among other things, covers the purchase of the material, the size and in particular the position of characters on the keyboard. The report draws attention to the electric typewriter, which has the outstanding advantage of permitting the worker to turn out quicker work with many copies without fatigue.

Mr. Eppler emphasizes in his report the extraordinarily wide spread of the typewriter, which is used for innumerable purposes for correspondence. He notes especially in the connection its application to the preparation of freight notes which permits of a simplification of the accounts and, because of greater legibility, brings substantial advantage to railway management.

Special reference is made in all three reports to the arrangements which couple typewriters with other apparatus, especially with calculating machines and punching machines. The electric calculating machines and typewriters, which are in use in a few offices of the Reichsbahn, are dealt with in detail.

Calculating machines.

Calculating machines have been extraordinarily widely introduced. The three reports are deeply concerned in this and

as a result the various machines here presented are thoroughly described : the simple adding machines, the adding and subtracting machines, the accounting machine with more than one totalizer, the 4 special machines. There is an extraordinary number of varieties and types of these machines whose application is decided by the nature of the operations to be carried out. The reports of Messrs. Bruneau and Boistel d'Welles and the German report quote numerous examples of the objects for which such machines are used by the railway administrations, and which individual type is chosen therefore.

Of the various machines mentioned in the reports the addressing machines deserve special attention; these machines make the rapid writing of addresses on envelopes possible, and are suited for the printing of names on tickets and lists. This makes them useful for very many purposes, namely for salary and wage calculations and for the making out of pay sheets.

Ticket printing machines.

The ticket printing machine is fully dealt with in the reports of Messrs. Bruneau and Boistel d'Welles; Mr. Eppfer does not mention these machines. Messrs. Bruneau and Boistel d'Welles put forward, as the chief advantage of these machines, that by their use the ticket issuing service is simplifyed and lightened considerably, especially in regard to the accounting. These machines are not at present in very wide use; the report confirms the fact that only 4 administrations have these machines in use. These are the Czechoslovakian State Railways, the Dutch Railways, the French Est Railway Company and the French State Railways; it is stated that the French Est Railway Company has definitely decided to apply the system to the whole of the suburban traffic of its new Paris station. The French State Railways also intend to apply ticket printing machines to the operation of their densest suburban traffic at the St. Lazare station, as well as for the working at Montparnasse where the space is very restricted.

The Reichsbahn on the other hand, uses these machines in large numbers; the German report describes, in addition, the high speed printers introduced for urban and suburban traffic, which permit of the specially rapid handling of passengers at the ticket windows.

Cash registers.

The employment of cash registers deserves very special attention; they are designed to simplify and expedite the handling work connected with goods traffic. On the Reichsbahn they offer special advantages for express goods traffic; the German report gives as an example of this, a complete description of a typically arranged express goods station.

D. — Summary.

1. The efforts to make the operations necessary for the carrying on of correspondence, accounting and statistical work more economical, are a part of the great question of measures to be taken for rationalization. The objective may now and then be reached by pure and simple rationalization, but more generally by rationalization coupled with mechanization.

2. In order that when choosing the means, the appropriate ones may be selected, it appears worthy of recommendation, that every administration should set up a special department whose duty should be to investigate uniformly the basic questions concerning rationalization and mechanization and which, with its accumulated knowledge, should stand behind the detached departments in an advisory capacity.

3. The common axiom governing mechanization should be : The introduction of office and similar technical apparatus

is justified when, after taking into consideration purchase and high amortization costs due to rapid depreciation, savings are made or indirect advantages, such as the quickening or improving of work, are gained, such as will offset the costs.

4. Accurate judgement on the economic results of mechanization presupposes the existence of comparative accounting. The prompt production of the costs incurred by the introduction of machines and the working out of the costs of mechanical methods should therefore have careful attention.

5. The degree to which machines are occupied has considerable influence on the cost of mechanical operation. The policy of keeping the machines fully employed is therefore of the utmost importance in the organization of the work; in many cases, the centralization of work will be a preliminary step.

6. The office machines, mechanical installations and similar apparatus at present to be found in the use of the railway administrations, are of extraordinary diversity; on account of the continued progress in this sphere, each administration must in future choose in the light of the common point of view previously developed, the machines which are best suited to its particular needs and operations; an interchange of ideas at a later date is to be recommended, on the experience accumulated, especially that concerning machines built solely for railway purposes such as ticket printers and the like.

7. An advance of the very greatest importance in statistical and accounting operations is to be seen in the introduction for statistical purposes of machines (the so-called perforated card machines). Their advantage lies in the possibility of carrying out investigations more rapidly and more accurately and in the possibility of deepening the researches and opening up areas which could not be reached by purely manual methods. Enquiry is therefore possible into questions which, up till now, have been closed to investigation, especially on the economic side, and this makes possible the elucidation of important scientific problems regarding railway operation (cost problems).

8. The wider general introduction of the perforated card system will provide advantageous possibilities for international co-operation, especially in the matter of reciprocal accounting and particularly for the question of international traffic statistics. It is recommended that developments in this direction should be watched, and that later, at the appropriate time, they should form the subject for further discussion.

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QUESTION XV.

(CO-OPERATION OF THE STAFF TOWARDS INCREASED EFFICIENCY AND ITS PARTICIPATION IN THE PROFITS) (1),

by RAFAEL MARIN DEL CAMPO,

Special Reporter.

SUMMARY.

I. — Object of this special report.

Unless I have misinterpreted the instructions of the Permanent Commission of the Congress, the object of the present work is to prepare a summary of the three reports drawn up on this question and to summarise them in such manner that, in the briefest space possible, the essential analogies and differences in the American (No. 1.), the French, (No. 2.), and the Spanish (No. 3) reports shall be clearly brought out.

Seeing the little space allowed for this compilation, and the very special nature of a subject presenting such difficulties (co-operation of the staff towards increased efficiency and its participation in the profits), it seems to me that these essential analogies and differences can be *neither more nor less* than those affecting the following two main aspects.

First aspect.

How each of the three groups of reporters has understood the subject « co-operation of the staff towards increased efficiency and its participation in the profits », and how the problem contained in the rubric has presented itself to the Companies to which each group sent its questionnaire.

Second aspect.

Conclusions made by each of the three groups of reporters as a result of their presentation of the problem, from the replies received to their questionnaire, and from the study made of both.

After having carefully studied the three reports first of all separately and then comparatively, it appears to me to be clearer and more methodical to summarise each separately, starting with the French report No. 2, then the American, No. 1 and finally the Spanish, No. 3, and to complete the work by a general summary and conclusions which, to fulfil the task confided to me, I have to formulate and to submit to the 4th Section of the Congress for consideration.

(1) Translated from the French.

(2) See *Bulletin of the Railway Congress*, November 1929 number, p. 2533.

(3) See *Bulletin of the Railway Congress*, July 1929 number, p. 1125.

(4) See *Bulletin of the Railway Congress*, January 1930 number, p. 215.

A last preliminary remark : the complexity, the importance and the immense consequences at the present time of the problem, which has not been considered by the Congress for 41 years; the variety of conceptions, or of doctrine, or at least of the points of view from which each group of reporters has considered it in order the better to indicate the road to be followed for its future solution, a solution which has still to be found; and then the circumstance that I myself belong to one of these groups; all this has obliged me to sum up the three studies mentioned above with the most punctilious exactitude. For these reasons parts II, III and IV of this work will be not so much summaries as extracts, that is to say there will not be a single paragraph in them that is not to be found in the original reports Nos. 2, 1, and 3, respectively. Thus, my only fault, or my sole merit, in the three parts below will be that I have badly selected the passages I have been careful to *copy literally*, from which to build up as faithful and synthetic a table as possible from the points of similiarity and difference existing between the French, American, and Spanish reports under the two aspects alone under which they have been considered in the present report.

II. — Extract from the French report by Messrs. Soulez and Bloch.

First aspect. — How the subject was understood.

In the second part of the 19th century, when the transformation and concentration of industrial and commercial undertakings became more marked, the problem of increased output became very urgent in all countries.

Many formulæ dealing with payment of wages have been invented and applied in turn, all of them having as their object the establishment of a satisfactory balance between the needs of production, that is to say the increase of production and the reduction in cost price, and the claims of the workers which, to only quote the principal, have in turn been : increase in pay, reduction in the hours of work, regularity of employment guaranteed by insurance against unemployment, sickness and incapacity, the increase of pay in terms of the cost of their families, and finally more recently benefit of a pension to which the master contributes, with an annual holiday with pay.

From observations made, it soon became evident that payment solely based upon the hours of duty would not form a proper solution of the problem, and that in order to increase the output it was necessary to interest the employee in the production by paying him a supplementary salary calculated upon his individual output.

The various formulæ invented have therefore given to the staff a supplementary payment either by means of bonuses granted by the employer as he thinks proper or by the payment of premiums.

Amongst the systems of payment based upon output, can be quoted :

1. *Task work*, which diminishes the overhead charges but has no effect upon the unit cost price as the production grows;

2. *Piece work*, which has the same drawback as task work and does not oblige the workman to make the best use of the tools or materials at his disposal.

Furthermore, task work as piece work can sometimes cause the workman to make an abnormal effort which he cannot maintain for a lengthy period and which consequently can upset the regular running of the undertaking. In addition, any error in fixing the piece prices is either to the disadvantage of the workman or the master; it is consequently necessary to revise the rates at intervals and this leads to disputes and difficulties

As a result the masters have endeavoured to substitute, for the above two methods, the following :

1. *Premium - work* (Rowan, Halsey and Atkinson systems) in which the workman does not receive the full price for each piece produced, but instead a premium, added to the guaranteed hourly rate : the workman is paid part of the saving resulting from the economy of time he has made, the other fraction recompensing the expenses incurred by the management in improving the tool equipment and the conditions under which the work is done. The system also most often carries with it penalties for bad work, spoilt material, or insufficient output.

When applying the system, the time allowed for the manufacture of each piece is determined either by timing with a watch, or from the result of previous work. As the premium decreases after a certain output, while it stimulates the efforts made by the workman it does not incite him to overwork, and thereby avoids any falling off in the quality of the work or wastage of parts and materials.

In certain branches of industry and commerce, the premium or commission is based upon the output, upon the receipts, or upon the total business done by the receiver, the seller, the office or section of the undertaking.

In the systems of remuneration analysed above, the additional salary corresponds to the exceptional efforts of the workman. It is obtained by a formula previously known and is paid at once at the same time as the salary properly speaking.

Another idea has come very much to the fore : the need for interesting the staff in the consumption of consumable stores as a result of which premiums are paid for economy and investigations made into all causes of bad working or of damage.

All these kinds of premiums fall into the same class and have as their object the encouragement of the staff to carry out conscientiously *their daily personal work:* but it was logical to go further and to interest the staff in the general running of the business by making it participate to a certain extent in the profits of the business employing it.

In the systems of profit sharing the staff is paid a part of the net earnings at the end of the financial year.

The proportion of the earnings to be distributed is fixed by the head of the undertaking, the proportion varying according to the undertaking, being by equal parts or with the introduction of one or several factors, such as total of the salaries, length of service, grade, importance or value of services, family charges, etc.

In some cases the distribution is by individuals, the amounts being paid in money or capitalised in an individual book; in other cases the share is collective, its amount going to a collective fund for sick benefits, old age, or pensions.

Profit sharing has only been introduced in relatively few cases in France and Belgium. In France participation is moreover prescribed by law :

1. In manufacturing companies placed under the law of the 18 December 1915;

2. In mining concessions or workings granted after promulgation of the law of the 9 September 1919.

In other undertakings, to the number of about 150 in France and 50 in Belgium, participation in the profits is entirely due to private initiative. With few exceptions, so far as can be judged from the replies we have received, it appears that sharing in the net profits has only had a slight influence upon the amount of work turned out in the industry.

Profit sharing, moreover, has not prevented certain difficulties arising, and

these have not facilitated the extension of its use. It does not in fact make it possible to proportion the share due to the workman to his individual output, and above all his efforts are not immediately rewarded.

* * *

It should not however be forgotten that the method of payment and in particular the institution of premiums or gratuities for good output only forms one of the factors in improving the production given by the labour employed, because the organization of the work and the use made of the labour are factors of at least equal importance.

In fact if the workman as regards his trade is so placed that he finds himself supplied with work regularly, and supervised in his craft by chiefs who really know their business, and who are rather advisers than controllers, and if he feels himself, in brief, the centre upon which the whole organization converges, he works well, carried forward by the task itself and encouraged by the feeling that his work is of value.

Furthermore, the professional feeling of the workman, as well as his personal interest, also constitute factors of the first importance as regards output, which have to be taken into account. Moreover the rational organization of an undertaking ought to be investigated before questions of remuneration, not only on account of its prime importance but also because these latter very closely depend upon the former, whereas the contrary is not the case. As a matter of fact, if a workman is so paid that his earnings depend upon the amount he produces, he will see, for reasons outside his control, his salary suffer considerable variations, according to the conditions under which his work is organized. A method of payment which would be satisfactory under certain conditions would be inacceptable when the work is organized in another way. It is then logical to investigate and to improve the organization of the work in a methodical manner, and to obtain the highest output that these improvements make it possible to obtain before making the workman interested in his production. Once this procedure has been realized the latter will receive a fair remuneration founded upon stable and definite conditions of work and any variations in it will depend solely upon is own activities.

An examination into rational methods of organization as a whole does not enter into the scope of this report. The résumé above has as its object to place the question of remuneration in its true place, that is to say, to show that it only forms a part of the greater and wider problem of rational organization.

* * *

According to the plan of our questionnaire, our investigations will be divided into two parts, as shown below :

First part.

Steps taken to improve the individual or collective output.

Chapter I. — Premiums and gratuities common to employees of all Departments.

Chapter II. — Premiums and gratuities granted to employees in the Operating Department.

Chapter III. — Premiums and gratuities granted to men in the Chief Mechanical Engineer's Departement and in the Locomotive Running Department.

Chapter IV. — Premiums and gratuities granted to men in the Permanent Way Department.

Chapter V. — Measures affecting temporary labour or contractors employed by the Railway Company.

Chapter VI. — Premiums and gratuities : special cases.

Second part.

Chapitre VII. — Measures taken to interest the staff in the general financial results of the undertaking.

Second aspect — Conclusions.

The above investigation that we have carried out on all the branches of activity of Railway Companies, shows, that most of the Railways and their departments have systems of gratuities and of premiums which assure a more or less considerable additional remuneration to the staff.

The conclusions which this investigation has brought out appeared to us capable of being summed up in the following way :

1. The growth in the institution of gratuities or of premiums, in order to obtain greater efficiency, shows the interest the Railways have taken in this system.

It is evident, in fact, that gratuities or premiums, result in the zeal and activities of the staff being stimulated to a greater extent and in a better way than can be realised by the normal remuneration, which cannot be exactly proportioned to the efforts and daily output of each man.

2. The necessity for defining the amount of a premium to be granted by formulæ which make it possible to proportion the amount of the supplementary allowances closely to the increase in the efficiency, has been recognised.

As a result, it has been necessary to accurately define the output required at the same time as the corresponding value of the premiums.

In order to arrive at this, several methods are in use.

In some cases it has been thought sufficient to codify the methods in use and to fix the figure for the production according to the results that these methods make it possible to attain.

Certain undertakings have endeavoured to arrive at greater accuracy when fixing the production rates after which a premium is due, and have not been satisfied to adopt the methods of working confirmed by custom. They have carried out a systematic investigation into the processes giving the geatest efficiency. They have in this way been automatically led to take into consideration the question of the scientific organisation of work, and to recognise that their studies should, to be logic, precede — as we have pointed out in our precis — that of the premiums for efficiency.

Although the questions of rationalisation are outside the scope of the present report, we think it useful to briefly indicate the processus of the operations to which the Railways who have taken into hand this investigation, have been led :

a) Setting up of an industrial accounts office to ascertain the indirect charges.

b) Modification of the establishment by a carefully thought out specialisation of the management staff.

c) Detailed investigations into each operation in a unit of production so as to find without taking into account previous practices, the methods leading to the greatest output and to the lowest cost price.

d) Exact definition of the condition of work in each particular case, so that the methods, tools, speed, etc... of each operation, shall be completely defined.

e) Investigation into the time to be allowed for each of these operations, taking into account the precise conditions laid down as above.

f) *After completion of the preceding investigations and with the certitude*

that the results to which they have led cannot be surpassed by improvements which are in the control of the management, introduction of output premiums.

It is obvious that these stages are more easy to follow rigorously when organising repair work than when dealing with traffic operations. We think, however, that this presents a logical staging of the work of rationalisation and that there is every interest in following it up as closely as possible.

In any case, and no matter what method be employed when instituting these premiums, it is only equitable that any improvement in the output recorded after their institution, should result in the staff concerned being given an increase of pay proportional to the saving made by the shop using it as a result of the additional effort of the staff.

3. The enumeration, though incomplete, of the formulæ in use given in the above report, show that the premiums and the gratuities are most variable in their objects, in their rates, and in the way they are applied. In our opinion there does not appear to be any reason to endeavour, in order to satisfy an excessive desire for unformity, to suppress the differences necessitated by the varied organisations, the multiplicity and variety of needs, the relatively very different importance of the same factor on the various Railways.

4. None the less, it is desirable that as far as possible, the formula which governs the award of gratuities and premiums for output, should be simple and understandable by every one.

5. In order to avoid arriving at results opposite to those sought it is advisable that the recompense should be carefully gratuated in any one place of work according to the difficulty of the work done by each man and according to the output given, so that each man can readily see that every exceptional output results in an exceptional increase in his pay.

6. It is also desirable, in every case in which the useful effects of the work done by each man can be measured and in all cases in which the individual output can be measured, that the premium should be given a personal and individual character.

7. It has been observed, moreover, that one of the factors in the efficacy of the exceptional gratuites and of the output premiums, is the speed with which they are paid, or at least with which they are published, in the shop itself, the output recorded, and the amount of the premium granted for this output.

8. Seeing that an improvement in the output results in an increase in pay, it is certain and logical that any reduction in output, or wastage of time, tools, or materials, should be punished by a reduction, or even by the suppression of the premium or of the gratuity.

It is not always possible to bring home to the man concerned the consequences of his mistakes and bad practices, but each time that this can be done, it is desirable to determine who is responsible, and to give to the amount withheld — as to the premium itself — a personal and individual character.

In the same way as for the premium itself, the speed with which the reductions or suppressions of premium are made is a very appreciable factor in their efficacy.

9. As regards the management staff, it is desirable that the gratuity or premium should be based upon the whole of the factors which affect the output of the shop or of the gang controlled, and even, if possible, upon the immediate and subsequent consequences of the work of the shop or gang. It is desirable moreover that the premium or gratuity should be proportional to the per-

sonal influence exercised by the member of the management or directing staff.

10. As regards the participation of the staff in the general results of the undertaking, it can only be paid to the men concerned after the end of each year. The men cannot therefore, when they give an additional output, realise the supplementary gain that will be paid to them; the encouragement that any such participation can give psychologically varies therefore with the training and the intellectual qualities of the staff affected.

Experience shows that the greatest effect is exercised upon the management staff. It is consequently to this class of staff that it should be more specially applied.

III. — Extract from the American report, by Mr. Cook.

First aspect. — How the subject was understood.

In order to simplify treatment, Question XV is divided into two parts : 1. Co-operation of the staff towards increased efficiency; 2. Participation in the profits. This is done to permit definite treatment of each part as it is found operative in railway organizations, and to avoid omission of reference to co-operative measures resulting in increased efficiency despite the lack of any definite plans for participation in the profits.

The questionnaire which was sent to member Railways encouraged full latitude in responses, and though it contained suggestions of specific means for increasing efficiency and plans for participation in profits known to be in use in various industries, no limitation was imposed and none was recognizable in the replies.

A. — Co-operation of the staff towards increased efficiency.

The part of the question relating to « Co-operation of the staff towards increased efficiency » will be considered first. There is complete recognition of the fact that the elemental purpose of all railway organizations is efficiency of performance, and that the efforts to secure that efficiency do not terminate with the establishement of the various organizations, but are ever continuing in definite channels to meet the constantly enlarging demands placed upon them.

Hence the purpose of the questionnaire was to develop those advanced measures which may have been outgrowths of necessity to counteract unwholesome propaganda following the world conflict, or may be the urge of experienced and inspired managements in their endeavors to place the transportation industry as represented by their individual organizations in the lead of all industry in improvement of its efficiency.

General policy of the Railway administrations with regard to the co-operation of the staff towards increased efficiency.

A leading carrier re-stated the underlying purpose of railroad organizations in this introductory paragraph of its response :

« We have no fixed method in use to secure the co-operation of the staff in increasing efficiency. The personnel of our officials from the President down and their manner of treating their inferiors is this company's greatest asset. Any employee who has anything worth while has access to any official of this company, and when he comes in contact with that official he is accorded such treatment that he feels that he is a part, and an important part, of the organiza-

tion, and he is glad to co-operate in any manner possible. »

Another railway replies as follows :

« The plans employed to secure co-operation in increasing efficiency are based fundamentally upon the development of capable, alert, and enthusiastic supervisory forces, trained in the economic problems of our railroad, and loyal to the purposes of the management. The general scheme followed in bringing about this co-operation is developed around a plan of departmental organization, whereby the various grades in the supervisory forces are grouped into units for the detail consideration of problems and the careful co-ordination of the work of the groups to secure the best results. »

A further reply runs as hereafter :

« In order to emphasize the need for co-operation, special meetings, attended by company's officers and all grades of employees, have been held at various centers throughout the system with the object of encouraging the interest of the staff in all matters affecting the development and economical conduct of the company's business, the idea being to impress upon the staff that the interests of both employer and employed in developing the business and eliminating waste were identical. »

The foregoing indicates the general policies of railways of different countries in respect to co-operation of the staff towards increased efficiency. Specific references to the more important measures which prevail are given below.

1. — CO-OPERATIVE MEETINGS.

Various methods of grouping officers and employees for the general purpose of securing co-operation in the entreprise of the railways are employed.

. . . .

The purposes of these co-operative meetings are similar irrespective of country. In general, the subjects discussed relate to safety, conditions of service of employees, reduction in operating costs, attraction of new business, recommendations for improvements in property and practices, and general betterment to the service. A leading railway states the case in this way :

« We are of the opinion that the opportunity afforded by these meetings provides a convenient method for the frank interchange of views between the officials of the company and the rank and file of the men, as the representatives of the latter who attend the meetings are required by their colleagues to report to them the result of the discussions that have taken place with the company. By these means a better understanding of the company's difficulties is generated amongst the staff to the mutual satisfaction of both sides. »

. . . .

In the reports submitted by the responding railways of all countries relating to co-operative meetings there are the testimonies of the officers of the individual companies to the improvements in mutual understanding of the common problems of management and labor which have resulted in increased efficiency in operations. The consensus of advice received is that among the definite measures used to enlist the co-operation of the staff, these co-operative meetings hold the lead as the most effective means of stimulating and retaining active interest of employees in affairs of the companies.

2. — SUGGESTIONS SCHEMES.

These are closely linked with co-operative meetings, but are considered separately by reason of their adoption where co-operative meetings do not prevail. On some railways they supple-

ment the systems of co-operative committees, and are conducted simply by invitation of the management to all employees to submit in stated form any suggestions which may aid in the progress of the railways. In some cases a printed blank form is used and employees encouraged by printed circular to offer their suggestions.

. . . .

The way in which some other companies deal with suggestions is expressed in this reply from a large railway :

« This railway encourages suggestions from employees, that will improve the service. An employee who has a suggestion submits such to his superior officer by letter, and careful consideration is given to each suggestion made. If found practicable, it is adopted and in any event, the employee is informed of the final disposition made of his suggestion. »

3. — EDUCATION AND TRAINING.

Here again there are reported the most definite activities in provision of facilities for education of employees.

4. — MISCELLANEOUS.

Numerous other measures providing for co-operation of the staff towards increased efficiency which do not require geographical designation to indicate their value nor extended description to show their purpose were indicated by the replies received to the questionnaire.

. . . .

B. — Participation in the profits.

Were discussion of this phase of Question XV limited to participation in the profits as represented by profit-sharing plans and bonus payments from the net profits of the companies, operations as practiced to some extent in other industries, it could be said of the railroads in the countries embodied in this report that it does not exist.

Such limitation, however, would not be justified for it is recognized that concerning profits there are elements of management affecting the earnings and expenditures of enterprises other than the mere receipt and payment of monies.

What are profits ? The term cannot be restricted simply to the difference between earnings and expenses for operations; neither may it be limited to the amount remaining from yearly gross income after payment of all corporate indebtedness of the year, for that too would ignore the maintenance of the integrity of the investment.

In these times of mass production, consolidation of facilities, inter-relation of industries, progress in methods of manufacturing and invention which may leave obsolescent an otherwise substantial industry, and in all the economic movements with which the transportation industry is vitally connected, it is essential that railroads in common with other industries maintain such conditions in connection with their employee relations as will insure perpetuation of their corporate stability. A satisfied, loyal, and energetic personnel is credited with being one of the most important assets that any industry may have, whether it be the largest corporation of the century or an individual enterprise. It cannot be said then that the measures which have been adopted to bring about this contentment and loyalty have not a very considerable relation to the profits.

Those policies and measures which therefore have been adopted with the purpose of increasing the efficiency of the enterprise as well as adding to the remuneration of the employees, whether directly or indirectly, have accordingly been given consideration in our investigation of this phase of the question.

The measures which we will here re-

view, it must be understood, however, are not dependent on the net profits of the companies. They have in general been adopted as positive expenses incident to the companies' operations and have thus appeared as items of actual expense in reduction of net income whether or not the influence of their operations may indirectly have resulted in actual increase of net income through reduction of expenses and increase in gross earnings.

. . . .

Second aspect. — Conclusions.

Co-operation of the staff towards increased efficiency is a prime objective of railway managements irrespective of countries included in this report. It is being developed by the following measures :

1. The personnel of officials from chief officer down to the rank and file is the greatest asset of railways in creating and maintaining co-operation of the staff. The selection for supervisory positions of capable, worthy employees who will loyally support the esprit-de-corps which is responsible for the continuation of co-operative action by all employees, is the first care and purpose of railway managements. Prospects of promotion provide normal and effective incentive for continued interest in companies' affairs.

2. Employee representation in management as reflected by the organization of special groups of officers and employees known as railway councils, works committees, co-operative committees, etc., having for their purpose increase in efficiency and improvement in service, prevails on many railways of Great Britain, United States, and Japan, and is credited with large accomplishment towards increasing efficiency.

3. Co-operative meetings of committees and councils at stated periods with scheduled order of procedure have been responsible for development of a spirit of friendliness and goodwill of extensive though un-measurable value to the railways in securing wide expansion of co-operative activity among employees.

4. Proposals of measures for improvement of working conditions of employees, safety, attraction of new business, conservation of materials, suggested improvements in machines, in manual practices, and general betterment of the service, have been received at these co-operative meetings and for the major part subsequently adopted in such numbers at to warrant credit for increases in efficiency which otherwise would not have been obtained. The following record relating to activities of two organizations typifies the accomplishment :

Organization.	Period operative.	Proposals submitted.	Per cent adopted.
Government Railways of Japan (System) . . .	8 years	37 919	36 %
A railway in the United States (mechanical department) . .	5 years	22 629	85 %

5. Suggestions schemes are in some cases adopted in lieu of co-operative meetings, and proposals of items of mutual interest for improvement of the service similar to those described in the preceding paragraph are invited either by conference with a supervisory officer, by originating a letter or by use of a printed blank form distributed for the purpose by the management. Measures increasing efficiency which in the past at least would not otherwise have been offered have been adopted to the advantage of the companies. This plan is largely used in England. One railway in that country reports 48 960 suggestions received in 11 years, 5 215 being forwarded during 1928.

Comments on value of co-operative meetings and suggestions schemes.

Co-operative meetings and suggestions schemes alike are effective in developing proposals for improvement of the property, working conditions, business and service, and are approximately of equal value. Their worth in either instance is dependent upon the organization and activity of those who direct the movement.

The co-operative meetings hold an advantage through the provision of facilities for personal meetings of representatives of management and of employees in discussion of items of mutual interest. This engenders a spirit of good-will more far reaching than do the suggestions schemes and gives to the co-operative meetings an appreciable advantage.

Awards for meritorious suggestions are given in Great Britain, Australia, other Colonies and Japan. In the United States awards are not given; customarily the machinery of the co-operative meetings functions to give consideration to all proposals at successive meetings until they either are adopted or withheld. Upon disposition, the employee suggesting is advised of final action.

There is evidence in the replies from various railways that numerous adopted proposals made by employees would not otherwise have come before the management for consideration. It is probable that most of them, as well as many others, would have been presented through intensive effort of supervisory officers constantly obligated to originate such suggestions, and from those who may have been especially assigned to study the situations.

The tangible value of the definite suggestions for improvements adopted is most difficult to establish and constitutes the largest impediment to payment of a suitable reward. None of the replies indicated definite relation between value of suggestion and amount of award.

There is also doubt as to the relative value of awards paid to individuals and the more intangible recompenses that come to employees whose fortunes as to compensation, by reason of the civil and economic establishment of the railways, are linked closely with those of the company by which they are employed, and who through that situation realize advantages that accrue jointly to the company and to themselves.

6. Education and training of employees has wide application in Great Britain, having for its purpose elementary education in railway affairs so as to improve general efficiency, and specific training such as apprentice courses, so as to qualify specially trained men for the more responsible positions. Schools are conducted by the individual companies; courses in outside schools also are included.

In Japan training schools are provided for unskilled workmen and additional training given in workshops outside the railway. Employees showing special interest may be transferred to a special institute or sent abroad for continuation of research.

In America, apprentice courses within the railway organizations and the use by certain companies of the courses provided by commercial railway institutes constitute the major portion of educational and training activities.

In all of these countries these added facilities are supplements to the opportunities for self-improvement afforded by the closely related positions and departments of railroad organizations.

7. Safety first committees and meetings.

8. Promotion from the ranks based on seniority and fitness.

9. Supervisory staff meetings.

10. Veterans' associations.

11. Union management co-operation.

12. Free transportation courtesy.

13. Railroad Young Men's Christian Association programs.

14. Recreational programs.

15. Material conservation conferences and publications.

16. Provisions for comfortable living quarters.

17. Annual prize awards for best improved track conditions.

B. — *Participation in the profits.*

Railways of the countries included in this report have no arrangements whereby their officers or employees participate in the profits by a distribution of net earnings through profit-sharing plans or bonus payments, as is the practice of some companies in other industries.

Considering however that profits are the results of a combination of managements' efforts to increase earnings, reduce expenses and perpetuate its property on a profitable basis, and that the maintenance of a loyal energetic personnel is its greatest asset in the accomplishment of its aims, the measures that have been largely extended by railway organizations to secure this contentment and loyalty are here considered as the contribution of the companies and the participation of the staff :

Bonus payments as a part of operation expenses. — Production bonuses in the form of piece work payments or bonus payments for handling goods at certain large depots, at timber loading docks, in workshops, and other special locations where practicable, are extensively used by railways of Great Britain, its Colonies, and Japan. To a limited extent only are they used in the United States, being restricted to the mechanical shops, large depots, and special operations as timber handling forces on but a few lines.

These incentives to increased efficiency are credited as being valuable, and managements using them report it to be the policy of the departments to extend them.

Gift or merit bonuses have application only in Japan where such awards are paid to meritorious employees and for commendable actions.

Benefit associations. — These are widely extended on all roads of these countries which have reported and they have been developed to commendable degrees of perfection in caring for railway employees. These features for their welfare are commonly provided :

Insurance, covering sickness, accident, superannuation, and death; savings funds and loan provisions. Relief departments or associations, mutual benefit societies, etc., are usually organized by the individual companies. Funds are provided by contributions from the members and by liberal support from the companies, who generally supply the facilities and administration in addition to other contributions.

Sick, accident, and death benefits, and superannuation pensions constitute direct disbursements to employees and their beneficiaries who suffer from these hazards. In addition there are provided hospital accommodations with skilled medical and surgical attention for member employees, which facilities also are extended to their families at moderate costs.

Savings funds for encouragement of thrift, and loan provisions for establishment of homes are fostered to the material advantage of employees.

Excepting of course government-owned railways, there are in existence on certain railways in all of the countries reporting, definite plans for purchase of stock of the companies, which is made available either at market price or on

more favorable terms as a further incentive to thrift.

Many other activities which stop short of paternalism but do add materially to the contentment and welfare of employees are variously provided and encouraged by railways in all of these countries. These cover :

Safety first programs;
Young Men's Christian Association quarters;
Rest rooms and mess rooms;
Facilities for social affairs;
Recreational facilities and programs;
Transportation privileges;
Staff magazines;
Vacations.

In conclusion, it should be stated that this report represents an attempt to collect descriptions of existing plans relating to co-operation of railway staffs towards increased efficiency and their participation in the profits in America, the British Empire, China and Japan. The effort to condense replies so as to record accurately and concisely the prevailing measures has been without prejudice to the plans, the railways or the countries.

It is hoped that inadequacy of expression will not be responsible for discount of the purpose and extent of the methods described, nor should omission of reference be construed always to mean lack of facility, to the disparagement of company or country or even of the railway industry itself in relation to other industries.

Neither does reference, non-reference, comment or lack of comment indicate criticism as to policy in use or non-use of any of the plans described. The question as to whether the benefits outweigh the disadvantages is one that must be decided in each particular case by the individual company.

There also was no attempt made to show the per cent of application which might have provided for comparisons between various railways or between the separate countries. Nor was the relation of the application of these plans to their use in other industries made subject of analysis.

The items described and those listed without description have been gleaned from replies to questionnaire, and though responses were not received from all member railways and were lacking from any railway in one country (China), the symposium that has been presented is intended to represent the status of the features relating to our subject as it now exists. It is hoped that it shall not altogether fail in the purpose.

IV. — Extract from the Spanish report, by Messrs. Marin del Campo and Canovas del Castillo.

First aspect. — How the subject was understood.

When the Permanent Commission of the International Railway Congress Association did us the honour of appointing us as reporters on Question XV for the countries indicated above, our first reflection was that we should have, before all, to ascertain the exact significance of this question, in order thus to be able to draw up in a satisfactory manner the detailed questionnaire which we should have to submit, through the channel of the said Commission, to the different railway administrations. This preliminary study was the more necessary, since the question XV will not be dealt with in any of the special sections of the Congress; neither the 1st, 2nd, 3rd nor 5th, but in the 4th section, which will have to concern itself with all questions of a general character or order. Moreover, it was imposed on us by reason of the form, at the same time wide and vague, in which the question at issue was formulated.

The wording of this Question XV : « Co-operation of the staff towards in-

creased efficiency and its participation in the profits » everyone probably knows what that means *grosso modo,* but perhaps people in general have not asked themselves why this subject thus formulated *figures in the programme of the Congress,* and for this reason all will not have had the opportunity of preparing an exact reply to this latter interrogation. If we are probably all in agreement to reply that the essential objective that it is proposed to attain by interesting the staff, as far as possible, in the railway revenue and profits is to increase the prosperity of railway enterprise, we shall, on the contrary, divide ourselves into as many groups of opinions as there are different conceptions of this expression : « *railway enterprise* », and before all of the more general one which embraces it, *i. e. industrial enterprise,* since the railways are nothing else than one of the most important industries, intended to produce and sell the merchandise known by the name of *transport.*

Thus, some say : « *Industrial enterprise* consists of manufacturing the goods or product in question at the lowest possible cost price, and selling it at the highest price permitted by free competition ». Such has for long been, and such still continues to be what might be called the *classic conception* of industrial enterprise. The most important practical consequences of this theory, or, in other words, its distinguishing characteristics, are : the greatest possible gain, *per unit of product manufactured,* for the manufacturer; wages as low as possible, and high selling prices. To attain this end, one is led to fight by all means the competitive regime, thas is to say, to employ all the means at one's disposal to prevent the downwards movement of the selling price. This struggle against competition is manifested in the most noticeable manner by the formation of trusts and other similar combinations.

These consequences, derived from the conduct of industrial entreprises built up in accordance with the classic theory or conception of which we have just spoken, provoked in the public a reaction against the owners of these undertakings, and it was decided to be desirable to try, on a larger or smaller scale, the system of *cooperative production* organisations amongst consumers, with a view to dispensing with the manufacturers; on the other hand, by irritating the working masses, they constituted the veritable germ and the principal element in the success of Socialism.

We may find, without going out of our professional world, a striking example of the first of these two systems in the numerous, large and sometimes gigantic *State Railway Administrations* which we know, and which, looked at closely, are neither more nor less than co-operative societies for the production of the merchandise known as transport, of which the citizens are the partners or shareholders, and of which the respective States exercise the management. And an example, not less striking, of the second case is the Russian communistic *experiment,* which is only a variant of the socialist system. It is convenient, of course, to qualify as *State Socialism* the creation of the great railway systems attaching to the first group, and to rank under the generic appellation of socialism the two groups of examples cited, a name applied indiscriminately in the two cases, for they both originate from a like conception of affairs, the *socialist conception,* born of the desire to destroy the consequences flowing from the *classic capitalist conception* of business, to the detriment of the working masses as well as of the public in general.

Circumstances of which the exposition and analysis would not be here in place have recently led to a conception of industrial enterprise which few people can have formulated with as much success as Mr. Henry Ford, if in fact anyone has succeeded in doing so, in

word and in deed, under conditions comparable with his. To sum it up, this new conception, which might be called the *harmonic conception*, consists of considering an industrial business as a harmonious association of three partners : the capitalist, the workers and the public, all the three of which should be equitably benefited; in other words, the system must tend : 1. to remunerate the workers by higher and higher salaries, so as to improve, progressively, both their working and social conditions; 2. to reduce unceasingly the selling price of the products manufactured; 3. to increase simultaneously, and following an increasing progression, the profits of the capitalist. This *harmonic conception* of affairs, far from being Utopian, appears practicable and — better still — a corollary of the modern *scientific conception* of industry.

. . . .

To express ourselves in a manner more synthetic and more exact, we shall have to say that the harmonic conception of industrial affairs leads automatically to the *increase of the purchasing capacity* of society in general, and *simultaneously* of the individuals forming it, and this becomes from day to day less impossible, thanks to the scientific and ever more extended use of natural forces.

As is pointed out by the protagonists of the *harmonic conception* of industrial enterprise, its interesting side, or — to express it better — its essential side is the rational basis of the system. They assure us that in its origin it is not inspired with a philanthropic spirit, and that if, in fine, the system is philanthropic, the fact is that it is only a question of a *scientific conception* of affairs, born, rather than from sentiments, of love towards the worker and towards humanity, from the conviction that this doctrine, conceived by capitalists, is the only one which responds to the present needs of civilisation, and the one which, at the same time, can produce greater output and profits. For all these reasons, that is to say, owing to the rational strength of its principles, and because it conduces, according to those who support it, to increase simultaneously the material and moral prosperity of the capitalists, the paid workers and the public, its partisans conclude by the affirmation that the *harmonic conception* of affairs and the rules deriving from it will not be long in eliminating from industrial life the methods in use up to the present, offspring of the *classic conception* or of the *socialist conception*, or of the badly designed combinations which have been made or may be made of the two.

. . . .

« We are not inspired », they say, « by a sordid and in fact sterile and miserly egotism, nor, on the other hand, by an Utopian humanitarianism, today at least; we take Science for our only guide ».

* * *

Such were the first reflections that presented themselves to our minds when we received the nomination as reporters. Under their influence, we set ourselves to review the complete collection of the *Bulletin* of our Association, and to read attentively the reports of the questions analogous to Question XV of the Madrid session of the Congress, which were the subject of papers and of discussions in previous sessions, and constitute precedents which we consider ourselves obliged to take into account.

We will therefore commence the body of our report by a very succinct summary of these reports. Subsequently, we will cite certain important works which have appeared likewise in the *Bulletin* of our Association, and which, without forming part of the minutes of the sessions of the Congress, may be considered as suggestions made by the Permanent Commission so that we may all

take account of them. We will afterwards give an idea of one of the realisations which the harmonic conception or theory of industrial affairs has already achieved, on a small scale so far, it is true, in the domain of railways. We will go on to speak of the replies which the different administrations have addressed to us. And finally, as a conclusion to all these details, we will submit to the 4th section of the Congress the proposals which we judge to be the most useful and opportune.

* * *

The question of the participation of the railway staffs in the revenue and profits of the enterprise was raised for the first time in the second session of the Congress (Milan, 1887). It was returned to in the second session (Paris, 1889). Then, apart from a few minor and unimportant indications given in subsequent sessions, the subject did not figure in the questionnaires of any other session. Resuming consideration of this question today, therefore, it is well to take account of the fact that it has not been discussed by our Congress for forty-one years.

. . . .

With regard to the Paris Congress (1889), it is right that we should note the favourable impression produced by reading the report of Mr. Bela Ambrozovics, Ministerial Councillor of Hungary, not only because his work has much value from the orderly, clear and competent nature of the exposition, but also because, for the first time, he shows the importance of the questions of organisation and of moral order with regard to the subject studied by him.

. . . .

In the discussion of the question and of the report, the circumstance is worth noting that to the majority of those who took part the fact did not appear very agreeable that M. Ambrozovics attached a great importance to organic and moral questions. Reading today this discussion, at a distance of 41 years, produces the impression that Mr. Ambrozovics, perhaps in advance of his time, was of a type of mind superior to those who received so badly, as it appears, his organic and moral conceptions. At the present day, in 1930, the welcome offered to the ideas of Mr. Ambrozovics would assuredly be quite different, for even the capitalists, the large firms and high functionaries who, formerly, only took account of financial and technical data, are today unanimous in recognising the enormous and transcendent place that organic and moral factors occupy in the problem of the participation of the personnel in the revenue and profits of a railway, as of any other industrial enterprise.

. . . .

* * *

The examples we have just cited will suffice to show that before the European war many thinkers, and amongst them some eminent ones, who were also men of action, and of intense activity, useful and fecund, believed the moment had arrived for a radical transformation of the rules prevailing in modern industry, to increase and extend its *output* and its *profits*.

. . . .

If those who *thought* before 1914 thought thus, it is not surprising that those address themselves today to similar reflections who, since 1918, have commenced to *think*, and even the great majority of the immense multitude of technicians, industrialists, business men, professors etc., who are not in the habit of exercising their mental activity in the interests of the community, but *live from day to day*, march with the crowd — in a word, conduct themselves according to the standards taught by routine, learned and practised by routine. It is not surprising, we repeat, that in

the present critical times ideas and methods are opening up a path for themselves which in 1889 appeared wrong and perhaps Utopian. It is not surprising that, in all the professions, we see momentarily increasing the number of cultured persons to whom psychology and sociology no longer appear extravagant things, subjects for poetry or recreation, but *sciences* which, while still in their infancy, have already the rank and merit the name of sciences into which those must be initiated who occupy in industry a more or less important directive post, with the same attention and the same zeal as they devote to the study of technical and commercial questions.

But although these ideas have begun to become common, it is well that we should not tire of repeating, so as to combat the defenders and practitioners of the Roman *jus abutendi*, and also the charlatans who deceive the masses, that Science and Science alone can supply effective and decisive means to solve the most complex social problems raised by modern life, and in concrete terms, in order that Capital, Labour and the Public may be transformed from bloodthirsty enemies into cordial collaborators.

« Under various names », says Gustave Le Bon, « men in all ages have really adored only one divinity : Hope ».

It is proper, let us add, that the rich should hope to be richer, the poor that they may cease to be poor; but poor or rich, let us all also place our hope in Science, who, on the sole condition that we listen to her and follow her counsels, is the sole power capable of transforming, so far as is possible, our gilded human illusions into tangible realities.

* * *

Free from all prejudice, from all passion, from all personal interest, whether of class, enterprise or corporation; desirous of only letting ourselves be guided by the light of Science, but of *complete* science, of science understood as we have just explained; inspired, consequently, by the reflections made above, and having duly collected documentary information, we had to draw up a plan or draft of a detailed questionnaire relative to Question XV.

We divided this questionnaire into three parts : the first concerns the general systems and the *special* measures adopted to incite the staff *directly* (as individuals or small groups) to co-operate with the Administrations for the improvement of output and the increase of profits (premiums, bonuses, exceptional promotion, various rewards, facilities for acquiring shares and debentures). The second part relates to measures of all kinds (general operating organisation of the undertaking; wages; relations between railway staffs and administrations, including, should occasion arise, the representation of the former on the Boards of Directors, etc., recruiting; employers' organisations, etc., etc.), already taken with a view to inciting indirectly the whole of the workpeople to collaborate in the increase of output and the increase of profits. The third part is devoted to the *measures contemplated for the future, and above all to the fundamental conceptions of the management of each railway system with regard to the basis of Question XV of the Congress of Madrid*, to the measures which will be taken as a result either of their own railway experience or of the study of the theories elaborated and experiments made by all sorts of persons, entities and industrial undertakings, whether connected with railways or not.

By reason of their special interests, we think it advisable to reproduce here the following paragraphs of the Questionnaire :

« The reply to the 2nd part will be reduced to a very brief summary, intend-

ed in the main to make known the opinion of the management on the importance of the *indirect* measures indicated above, from the point of view of their effect on the participation of the staff in the revenue and profits of the railway, not merely applying these two terms, revenue and profit, to matters concerning the interest on the capital involved, but also regarding the railway industry as a « business », this word being used in the sense indicated in the definition of the contents of this part of the questionnaire. »

« In the 3rd part, there should be specially notified the view of the management on the present theories and tendency of the modern, *soi-disant* more intelligent capitalism, based on the devoted *co-operation* of the staff, high wages, very hard work preferably for a short day, and *simultaneously* on the reduction of the cost price, of which the essential idea is the new conception of the word « business » as a « public service », in which the interests of capital, labour and the public are essentially one, and of which the most striking application in the railway domain has been, for some years past on trial on the Detroit, Toledo & Ironton Railroad acquired by the Ford Motor Company, and to which Mr. Henry Ford has extended his general and well known methods of industrial operation. What the Interstate Commerce Commission has said in this regard, in an official document, should be noted : « It may be that this man will succeed in creating, in the domain of transport, something as sensational as certain innovations he has introduced into the domain of industry. »

« The reply to this 3rd part should be, needless to say, as matter-of-fact and as little literary as the others, but we would like the Administrations to understand that we consider this part as the most important of the three which make up the questionnaire, and perhaps the most outstanding of the Madrid Congress, in the sense that the replies made to this part 3, the discussion and the conclusions of the Congress in this regard may mark with a definite imprint — in our humble opinion — the physionomy of the social, financial, organic and administrative mentality of those who direct the railways of almost all modern nations. For this reason we — least of all — feel able to define limits of any kind to a reply to this question. »

. . . .

Appendix No. 1 is a copy of this questionnaire, which we reproduce in full in order to make its spirit known to the reader. It may be, indeed, that those who only read the questionnaire may not succeed in interpreting accurately our ideas and our aim. At least, this is what happened with the majority of the Administrations assigned to us by the Permanent Commission of the Congress, as we are going to explain later on.

Appendix No. 2 is a list of the Administrations who replied to the questionnaire. Comparing this list with that of the Administrations assigned to us, the relatively small number of replies will be noted.

It is well to state, moreover, that, amongst all the replies received, the majority content themselves either with simply acknowledging receipt, or with giving a few very brief particulars (sometimes none, because the undertakings in question have not established any staff participation scheme) which we are unable to use, or with communicating more or less numerous data and figures which did not however in any way solve the problem enunciated in the questionnaire.

It is for this reason that we said above that the majority of the Administrations has not properly interpreted our ideas, our design. And we will add that different Administrations, more or less indirectly, some in extremely clear terms, have given us to understand that in their opinion our questionnaire is *Utopian.*

These manifestations of opinion, as all those made in sincerity, must be received with gratitude, and are so by us, the more so that our sole ambition is to contribute to the discovery of truths, useful to society in general and to the railways in particular, and in view of our conviction that none, least of all ourselves, can have the right to be considered infallible.

In view of what we have just set forth, we can only recommend to the Permanent Commission, for total or partial publication in the Bulletin, the replies received from three Administrations.

. . . .

Second aspect. — Conclusions.

« Progress is not marked by a definite frontier which has to be crossed, but by *an attitude and an aura.* » These words of authority, transcribed above, return to the memory by a spontaneous concatenation of ideas, at the difficult moment of our being obliged to formulate our proposition to the 4th Section, just because it is precisely an attitude and an aura which, to judge from most of the replies received, one does not meet with in the *whole* body of railway administrations.

We have always believed that the associations which are so numerous in our times, from the League of Nations to the most modest societies, taking in on the way our International Railway Congress Association, composed of representative personalities, intelligent and animated with good will, meeting periodically, not to give orders which they have not the means to impose, but only for the purpose of stimulating initiatives and activities — we have always believed, we say, that associations of this kind have, above all, a primary mission to fulfil : *to adopt an attitude, to create an aura.*

Without doubt, the technical railway questions, relating to the track, to traction, etc., are extremely interesting; it is interesting also, to revert to our theme, to compare Administration with Administration, the number of francs received by each engine driver for a certain number of tons of coal saved during running, the annual bonuses granted to the staffs of the undertakings, etc., but certainly it is not these isolated points of view, unconnected, with limited horizon, which are the most important when it is a question of studying a problem having the gravity and breadth of that concerning the « Co-operation of the staff towards increased efficiency and its participation in the profits ». An Association such as ours has been created for something greater and more important. « Noblesse oblige », the adage says. If isolated individuals, however eminent, are only individuals; if Taylor and Ford and others of their stature study the problems and details of industry, apparently insignificant, with so much ardour and profundity, an Association of the standing of ours is much more obliged to follow the same line of conduct. If the main characteristic of great intelligences is to know how to raise the ordinary pettinesses of life to the plane of general ideas *whence, and whence only, one may presume to control men with success,* with how much more reason should a corporation like the International Railway Congress Association aspire to live on that high plane !

Let us return to our original idea. If we say, for example : « Premium received by traction staff for economies realised in fuel and other material », it is incontestable that this question must be in part the object of a study by the second section. In a similar way, it is to the first and to the third sections that it pertains to examine all the questions of the same kind relative to the corresponding services. But if we say : Co-operation of the staff towards increased efficiency and its participation in the profits » then there are two alternatives — either the question must be split up

into three parts assigned respectively to the 1st, 2nd and 3rd sections, each specialising in its own branch, the 4th section confining itself to combining and harmonising in one whole the partial conclusions of the three others, or else the problem must be studied exclusively by the 4th section, as has been decided in the present case, and, this granted, it is our opinion, seeing the age in which we live that it can only be contemplated with great breadth of vision.

To conclude, we have the honour to propose to the 4th Section of the Congress :

1. *That the deliberations of the Madrid Session on the question « Co-operation of the staff towards increased efficiency and its participation in the profits » should have as its object the examination of the question from the elevated point of view which, in our opinion and in conformity with what we have explained, is the one really appropriate;*

2. *That if the 4th Section considers that the preliminary study of Question XV is not sufficiently ripe for its deliberations to have the full effect desirable, as it did in the session of Milan 1887 for its question XXI, the same subject should be included anew in the questionnaire of the next session of the Congress, as it was decided then. It may be that there would be today better and stronger reasons for proceeding thus, seeing that the movement of modern ideas in the matter in question is much wider, more intense and more accelerated than at that time.*

3. *Finally, that if the 4th Section finds the above proposition justified, it shall consent to devote a part of its meetings in the session of the Madrid Congress to the more adequate drawing up of the detailed and uniform questionnaire which, under the same title : « Co-operation of the staff towards increased efficiency and its participation in the profits », should be addressed to all the Administrations forming part of the International Railway Congress Association, with the invitation to send their replies to the reporters to be designated, to the number of three or more, as now, to facilitate the work — the respective statements of which would form a basis for discussion in the next session of the Congress.*

V. — General summary and conclusions.

As soon as I was nominated Special Reporter for Question XV of the Madrid Congress, and in order to carry out my duty in the best way, I started by making two experiments.

One good day, shutting myself away from all distractions, I read the French report No. 2 very attentively and then thoroughly reflected upon all that I had just read. The mental atmosphere in which I found myself during these twenty four hours as a result of my reading was a mathematical atmosphere in which my eyes only saw algebraical formulæ, quantities and figures everywhere.

Several days after, I read the American report No. 1, in the same circumstances. The atmosphere in which I found myself was *psychologic, sociologic, organic and human*, in which my eyes saw *men in the flesh and bone*, with real railways and real railwaymen of the United States, England, Australia, or Japan.

My colleagues, Messrs. Soulez and Bloch have made a study which is rather analytical having understood that that was what they had to do, an analytical study may I say, as wide and thorough as noteworthy and meritorious, of *premiums and gratuities*, whereas Mr. Cook, whom I have not the honour of knowing personnally, has endeavoured to see and to make us see in a few lines also admirably written, as it were the complex

swarms of men who cooperate together, each in his own sphere, with a common objective, the efficient working and final prosperity of the different railways.

This same idea of Mr. Cook also inspired the Spanish reporters of whom I was one when drawing up the questionnaire which they sent to the European railways most of whom showed themselves so reserved and self contained that their replies were incomplete: Mr. Cook tells us he found the same thing, amongst others in the case of the Chinese railways.

A single difference worthy of mention existed between the questionnaires, otherwise substantially the same, drawn up by the American reporter on the one hand, and the Spanish reporters on the other. Mr. Cook only concerned himself with the present, whereas Mr. Canovas del Castillo and I considered what had taken place *in the past*, what was *occurring now*, and what would happen in the *near future*.

To sum up, my opinion, whether right or wrong, good or bad but given in all sincerity, is the following:

1. That the subject « Co-operation of the staff towards increased efficiency and its participation in the profits » ought not to be considered by the 4th Section of the Congress from a piecemeal point of view.

2. That it ought to be dealt with rather from a wide or panoramic angle by which the vision can embrace as completely as possible, all sectors, and especially the *psychologic*, the *sociologic*, and the *organic* sectors whence we can see the human being, the human man (if I may be permitted to use such an expression) the man who acts, not only in the present time, but also in the past, which is the antecedent and the explanation of the present, this point of view enabling us to foresee something concrete through the shadows in the near future.

3. That consequently I hold as final conclusion of the *special report*, the three conclusions with which my colleague Mr. Canovas del Castillo and I finished our report No. 3 and which are given in part IV of this report.

In spite of all the above, the 4th Section of the Congress in its wisdom will decide what it judges most desirable which will be — undoubtedly — what is also the wisest.

* * *

My first idea in drafting this special report was to close it with the conclusions I have just enunciated, but after reflexion I feel I ought to add something further.

Let us suppose for example that the 4th section makes the following remarks:

« You, as signatory to report No. 3, have every right to put forward the three conclusions with which you end your report.

« We also agree that the comparative study of the three reports No. 1, No. 2, and No. 3, provide a further weapon for defending your conclusions. But in allowing all this, and if moreover we give you our full approval to these three conclusions, you should not forget *you are our special reporter*, and that for this reason you have the definite obligation of suggesting to us the definite line of orientation our deliberations should take on the subject of Question XV, in a preliminary manner during the Madrid Congress, and in a final manner on the next Congress. »

I admit that I should not know what to say to such a well founded criticism, nor to such a solid argument. I shall limit myself therefore to stating definitely as a matter of information, — and in conclusion — what is the orientation which, adopted by the 4th Section, will conduct this section by a path which, from my way of seeing things, will be

the best, to a result at present unsurpassable.

It might be better to set out question XV « Co-operation of the staff towards increased efficiency and its participation in the profits » in the following way :

Methods used in the « past » and in the « present », and methods which could be used in the « future » so as to obtain from the staff of all categories of the railways their cooperation with the greatest efficiency in the growing prosperity of the railway industry, taking into account the different politico-economic « conceptions » which can be adopted in principle in the railway industry, and in view of the different politico-economic-socialistic conditions of each country.

I trust and hope that as a result of all I have just shown in this work and with the new statement of question XV, which, I have endeavoured to edit with the greatest precision, I hope, I say, that every one will clearly and definitely understand the very foundation of my ideas.

And in the case of this statement of question XV being approved — and I have the honour of proposing it as one of the questions for the 4th section at the next Congress — it seems to me that no questionnaire need be drawn up. It would, I think, be sufficient if the different Railway Companies were asked to read this special report carefully as well as the reports 1, 2, and 3 summarised therein, as in this way these Companies would have the necessary factors in sufficient numbers to guide their judgement when deciding the nature and structure of their respective reports.

[385 .(07 & 385 .586]

QUESTION XVI.

(METHODS FOLLOWED IN TRAINING OF STAFF, PROFESSIONAL, TECHNICAL AND ORDINARY WORKING GRADES) (1),

By Mr. BARTH,
Special Reporter.

Question XVI was dealt with in four reports presented respectively by Messrs.:

— L. C. Fritch, Vice-President, Operation, Chicago, Rock Island and Pacific Railway Company (2), for America, the British Empire, China and Japan;

— Bruno Schwarze, Reichsbahndirektor and Member of the Headquarters Administration of the Deutsche Reichsbahn Gesellschaft (3), for Germany;

— Barth, Principal Engineer, Headquarters of the French Est Railway (4), for Belgium, France, Holland, Italy, Portugal, Spain and their colonies;

— Mereutza, Assistant General Manager of the Rumanian State Railways (5), for all other countries.

The question of training the staff is one of great importance. The cost of the staff of a Railway Administration is indeed a considerable portion of its total expenditure, being about 2/3. Any variation in such expenses will therefore take the form of either a very marked economy or, on the contrary, a noticeable increase in operating costs. Now, at the present time it is hardly possible to imagine any reduction in the wages of the staff, rather, on the contrary, they are always increasing. It is therefore of the greatest importance that the resulting increase in expenditure should be met by a reduction in numbers. This can only be done by obtaining an increased output, and output can only be increased by an ever more thorough use of mechanical means and by improving the methods of working. The improvement of methods of working is in fact precisely the object of training the staff.

Such an improvement can be obtained with but little expense, as Dr. Bruno Schwarze notes, as he has calculated that the expenses incurred by the Deutsche Reichsbahn Gesellschaft in providing such instruction is only 0.015 % of the Company's total expenses, though the training of the staff is very highly developed on that system.

It is however necessary to remark that though it is very important to instruct the staff, it is no less important to ascertain first of all that the working methods taught are really the best. Now the railway companies who have studied this last question scientifically and tried to discover the best methods are few in number. It is to be feared that the methods taught are very often the result of traditional routine and that no systematic research has been taken to improve them. However an exception must be

(1) Translated from the French.

(2) See *Bulletin of the Railway Congress*, August 1929 number, p. 1315.

(3) See *Bulletin of the Railway Congress*, April 1930 number, p. 1197.

(4) See *Bulletin of the Railway Congress*, September 1929 number, p. 1905.

(5) See *Bulletin of the Railway Congress*, August 1929 number, p. 1453.

made as regards workshop methods, where American influence has led to a careful study of manufacturing methods during the last few years, and much improvement has been made. In other fields a scientific examination of the results that should be obtained and the best way of obtaining them should give excellent results; this could be done for example in the large shunting yards, the station offices, the headquarters offices, the permanent way and signal maintenance departments, etc.

However certain companies have set up committees composed of leading members of the staff for dealing with this subject. Those mentioned are due to the following railway companies : French Nord Railway (wagon repairs — carriage repairs — manufacturing : metal and wood working, saddlery); Belgian National Railway Company (main station operations — permanent way upkeep — repairs and upkeep of stock); French Est Railway (shunting yards — locomotive repairs); Polish State Railways (in hand); Swiss Federal Railways (conditions of work in stations).

As regards the question of training the staff nearly all the railway companies have realised its importance and the very complete and detailed replies given to the reporters show the care with which they have studied the question and the efforts made to solve the problem successfully.

However it must be stated, as one of the reporters notes with regret, that it is the great railways of the United States, which have always been the most progressive in so many matters, which appear to be least interested in the problem of training their staff.

* * *

In order to summarise the measures taken by the different companies, we distinguish on the one hand those concerned with the selection of candidates and their instruction previous to employment, and on the other those concerned with the instruction of the staff after engagement.

A. — Selection of candidates and instruction previous to employment.

The fundamental condition for obtaining a high class staff is to assure that it is well selected so as to choose only those who will be able to carry out their duties satisfactorily. This should be the first care of the railway companies.

The greater number do this.

For the *lowest grade occupations* where no special knowledge is *necessary* and the required qualities are mostly physical, such as labourers in the stations, labourers in the rolling stock or permanent way repair shops, permanent way and signal department labourers, etc., candidates are required above all to have good health, however most railways require them to have had an elementary education so that they can read, write and count. Others make them pass an examination which merely shows how much they know.

In order to be accepted as *skilled workmen*, candidates must undergo a practical test bearing on their particular occupation. On certain railways there are special regulations for such tests : the work to be done is always the same and the time normally required for its execution has been determined. Materials and tools required are usually supplied to the candidate.

For appointment to the *clerical staff* candidates are required to have a certain general education; they pass either an examination or a competitive test in writing, spelling, elementary arithmetic, geography, the metric system and composition. Besides this they can at their option take tests in foreign languages and typewriting.

For appointment to the *technical office staff*, tests in algebra, geometry, mechanics and machine drawing are added to those mentioned above.

Finally for appointment to the higher posts, diplomas are required.

On certain railways, candidates have to pass psycho-analytical tests; these are usually of different kinds. Some of them enable the rapidity with which the candidate reacts to the excitation of his nervous system (excitation by sight and hearing, power to stop rapidly any action begun) to be judged. Others enable his power to estimate speeds and distances, his excitability, etc., to be judged.

The railway companies which use these tests appear to find them satisfactory and estimate that by this means a great number of candidates who would eventually prove of small use are eliminated. However such companies are few in number and most of the railways are content merely to make candidates pass a test of physical fitness, as they consider that no special qualities are required for the duties on which such candidates will be employed at first and that subsequently the selection takes place naturally. It seems that they are in the wrong and that psycho-analytical tests should be made general.

Such are the methods by which the railway companies select their candidates. It must be noted moreover that a certain number of them, where the contract between employer and employee is more stringent, require a certain period of probation during which the candidate can be discharged if he does not prove satisfactory.

However a great many railways are not content with such a selection and prefer to give candidates a preliminary instruction; with this object some of them subsidise certain private institutions that give the required instruction; others have founded bursaries, while others provide such instruction themselves.

Certain railways have even set up a special organisation for this object. Moreover the instruction of the candidate is often preceded by a short period of apprenticeship during which he is examined by special officials so as to determine the employment best suited to his knowledge and capacities. This examination frequently involves the use of psycho-analytical tests.

For the actual instruction of candidates two methods are chiefly employed:

The first is to take the candidate as an apprentice and put him in charge of an official, or several officials in succession, responsible for instructing him in what eventually will be his employment.

The second is to give groups of candidates courses of instruction directed by professors employed by the railway.

These two methods may also be combined.

1. — Apprenticeship.

Employees of all categories undergo apprenticeship. For example, on certain railways, under-guards on trial are placed in the charge of an official for a period of several weeks with whom they will travel by day as by night in trains of different categories. Under the direction of this official they also learn, besides the geography of the railway, the different duties of brakesmen and conductors and take part in collecting and classifying goods as well as in the operations carried out on the road.

In most cases however the young men taken on as apprentices have a good general education and even possess university degrees.

The apprenticeship of these young men lasts several years.

In the permanent way department for example they pass a certain time in the drawing office, after which they are placed in the charge of a higher permanent way official with whom they learn the principles of maintenance and construction of the track, as well as the general rules and regulations of the company. Such apprenticeships are often preceded by a period spent in a workshop where the candidate is taught ma-

nual work and the operation of machine tools. Sometimes it also includes a period passed in the stores where the candidate learns the stores vocabularies.

On certain railways, and this seems an excellent practice, during his apprenticeship the candidate must lay in some track with the assistance of a gang of inexperienced men.

In the rolling stock and traction departments, apprenticeship includes a period spent in the workshops and another in the drawing office, and after these, service on the engines.

In the operating department the apprenticeship is served in the stations and in the headquarter and divisional offices.

This practical instruction is generally combined with a theoretical instruction given either outside, in institutions with which the railway has an agreement, or on the railway itself. In this matter certain railway companies have organised schools which will be discussed further on when dealing with the instruction of the staff. Here candidates are trained in telegraphy, accountancy, the use and working of signals, etc.... and in more general questions dealing with the working of a railway.

Certain railways give a preference to those candidates who succeed in passing a diploma examination during their apprenticeship.

The progress made is usually tested by one or more examinations which make it possible to ascertain if the candidate has acquired the necessary knowledge.

Sometimes the apprentices who have given satisfaction receive a supplementary general technical training at a University at the expense of the railway company while continuing to receive practical instruction on the railway.

Apprentices are not always guaranteed employment at the end of their training; some companies require a deposit from the candidate, his parents or his guardian, which the railway retains if he breaks his apprenticeship.

2. — Courses followed by candidates at or before their entry into the service of the railway.

We distinguish between the courses organised for candidates for manual employment and those for candidates for other kinds of work.

a) *Courses organised by the railway to train candidates for manual employment (apprenticeship properly speaking).*

The chief object of this apprenticeship is to supply the railway with good workmen for its rolling stock and locomotive running departments, its shops and depots (fitters, boilermakers, smiths, joiners, etc.) as also with supervisors. Certain railway companies also train rolling stock examiners, engine drivers, and men for the operating and permanent way departments.

This apprenticeship is very developed; several Companies have informed the reporters that they train several hundred apprentices every year.

On most of the railways where there are apprentices, preference is usually given to the children of employees or former employees. The children are presented by their parents or guardians. One company states that the apprentices in the permanent way department maintenance gangs who are the children of platelayers are left in the charge of the father who instructs them in their duties himself.

The age limits vary widely; usually the minimum age is 13, 14 or 15 years, the maximum age 16 or 17 years.

To be eligible for apprenticeship, candidates must usually have had a certain education and pass an elementary examination. There is however no preliminary examination on certain railways.

The apprentices are nearly always indentured. Under the indentures, the father, mother or guardian of the apprentice undertakes, in consideration of the remuneration received by the latter, to agree to his engagement at the end of his apprenticeship on the permanent staff of the railway if the apprentice so desires. The indentures also provide for disciplinary measures in case of unsatisfactory service; these may extend as far as the cancellation of the apprenticeship. The indentures also provide for penalties payable by either party in case of breach of contract.

On certain railways there are two classes of apprentices. The first class sign an indenture and deposit a security. The others do not sign any agreement and are paid less.

Moreover the agreement does not, as a rule, guarantee employment to the apprentice when he has finished his training. However certain companies guarantee it with the reservation that the apprentice has been satisfactory. Others give employment in practice without having definitely guaranteed it.

The apprentices usually receive wages which increase as their services become more efficient. Besides this, certain companies grant gratuities to those apprentices who deserve it, these being given at the end of the apprenticeship in the form of a savings bank book. On the other hand other Companies take paying pupils. In general on the English railways apprenticeship is free for the sons of employees while other candidates pay.

Furthermore the apprentices are sometimes required to pay a small sum every month as a security which is repaid when the training is completed. This money may be forfeited if the apprentice leaves the railway before the end of his apprenticeship or if he is dismissed for misbehaviour.

Certain companies which do not give the apprentice any theoretical instruction or only to a limited extent, will with certain reservations, bear the cost of any supplementary courses of instruction the apprentice follows outside.

The period of the training given to apprentices varies from two to six years.

First of all the training consists of instruction in a manual trade : that of fitter, smith, moulder, boilermaker, joiner, saddler, etc.; examiner apprentices also learn the use of hammer, chisel and file, etc. besides the knowledge they particularly require : repacking boxes, fitting brasses, lifting vehicles, names of parts, discovering defects, working of the brake, etc.; firemen are taught besides fitting, lighting up and firing and maintenance of engines.

For manual instruction the apprentices sometimes work in groups together or sometimes with the men.

Besides this purely practical training, certain railways give or arrange for their apprentices to be given a more or less advanced theoretical and even general instruction.

Sometimes the apprentices are merely encouraged to attend neighbouring schools; or else the cost of such courses are paid by the railway with the reservation that attendance must be regular and the results satisfactory; or again the railway gives bursaries.

Sometimes attendance at external courses is obligatory. Attendance takes place either during the day or else the evening outside working hours.

The instruction is more or less complete; it is sometimes limited to drawing and arithmetic, but usually it also includes other subjects, for example : accountancy, geometry, physics, chemistry, mechanics, technology, electricity, languages, political and industrial economy.

Moreover a complementary theoretical instruction is given on certain railways during the last year of apprenticeship to the most satisfactory apprentices. It is

especially intended to provide senior staff.

On other railways, the selection of the best apprentices takes place at the beginning of the apprenticeship and, during the last years of their training, they are given a better instruction distinct from that given to the ordinary apprentices.

For example the subjects taught are; in the first year : arithmetic, geometry, trigonometry, algebra, mechanics, drawing, and technology; in the second year : mechanics, geometry, physics, technology and political economy; in the third year : mechanics, electricity, the steam engine, chemistry and languages.

On certain railways, workshops have been organised and furnished with up-to-date machine tools with a staff capable of giving pupils instruction in the theory of the practical work they have to do.

Certain railways provide premises where their apprentices can be lodged and fed.

On all the railways where apprentices are taken, the training received is checked by means of an examination at the end of the apprenticeship. On most railways there are also examinations during the years of training. Generally the parents of the apprentices receive a report of the marks obtained, these being entered in a notebook which the parents have to sign periodically.

Generally a diploma is granted at the end of the apprenticeship to the apprentices who have given satisfaction.

b) *Courses organised by the railway companies to train candidates for employments other than manual.*

Certain companies in order to make sure of a properly trained staff have founded special schools where, before employment, candidates receive a good general instruction at the same time as they are being trained in the working of the railway.

The most usual courses are those for the traffic department employees, train men, drivers and permanent way maintenance staff.

The professors are usually railway officials.

The courses generally last several months. Moreover they are often combined with periods of practical training on the railway, either before or during the time spent at school.

For example, candidates for employment in the operating department are instructed in the following subjects : transmission and reception of signals by telegraph, goods and passenger services, signalling regulations, instruction about telegraphic messages, etc.... Courses are also organised in the main stations to teach candidates the duties of pointsmen; such courses deal with the working of points, the aspects and meanings of signals, methods for station working, etc....

The places in which such courses are given, like those intended for employees which will be discussed further on, are provided with models of station or permanent way equipment, signals of the regular type, telegraphic apparatus, etc....

B. — Instruction of the staff.

The methods of selection and apprenticeship described above have as their object to assure to the railways a well trained staff; we will now summarise the methods used to develop the instruction of employees.

Such methods are very important, as has been shown at the beginning of this report, as regards the efficiency of the staff. They can also be very useful from the point of view of preventing accidents : accidents to stock, but also accidents to employees themselves. The railway is unfortunately one of the most dangerous industries despite all the efforts taken to make it safer; but most of the accidents are due to carelessness in breaking rules. It is therefore very im-

portant to teach employees who work on the track or use machine tools, or work points, etc.... to respect these indispensable precautions.

Formerly the employee was left free to teach himself by the example of his companions, or by their advice and that of his immediate superiors. He learnt to work by working and by watching others work.

However a great many of the railway companies saw that this happy-go-lucky method was inadequate.

All the same, some of them were content to give their employees the chance of attending external courses of general instruction, or railway courses at the Universities or private schools.

This appears to be a more or less general method in England. One railway for example encourages its employees to follow courses at the University of London or other Universities, or in schools in the neighbourhood, or else to attend evening classes for shorthand, typewriting, etc.... Another has made an agreement with different English and Scottish Universities for a series of evening lectures on the working of a railway, its economy, legislation, geography, etc....; it gives its staff every opportunity and facility for attending these lectures. Another selects every year a certain number of employees who assist gratuitously at lectures and conferences given at the London School of Economics. It pays the expenses of those who become pupils or graduates of the Institute of Transport and gives rewards in kind to those who pass certain examinations.

The English railways also favour and even subsidise the creation of societies with the object of organising *debates* where employees discuss *among themselves* questions dealing with the running and organisation of railways. Reports are read on interesting transport questions and are followed by a discussion.

Such societies are stated to have a very good effect on the staff from the point of view of their instruction. They are in no way under official control, but high officials of the company play a great part in drawing up the reports and leading the discussions as well as frequently assisting at socials. Furthermore the railway company gives as much help as it can towards realising the objects of the society, notably by giving prizes; they also provide rooms for meetings.

It is certain that this system should give good results, not only by increasing the instruction of the staff but also by making it possible for different points of view about railway affairs to be brought together and compared.

Certain Companies also encourage *mutual improvement classes* which are held on Sundays in a good number of stations. The company supplies the premises, lighting and heating, models of machinery, and usually all useful material. The role of instructor is filled by some more highly trained employee.

Many railway companies, especially in England, put libraries and lecture halls at the disposal of their staff.

Others distribute to their staff specially edited reviews of their own on railway questions.

Finally others organise visits to other railways, especially abroad, so that their employees may study the methods used elsewhere.

However the method most often employed, and it would seem the most efficacious, consists of instruction given directly to the staff, organised by the railway companies on their own property.

Moreover, as one of the reporters remarks, it is very important to set judicious limits to the instruction given. The different categories of the staff must only be taught what it is necessary for them to know, but on the other hand they must know it thoroughly.

The material conditions under which

instruction is given are also very important. Sometimes it is more advantageous to instruct the employee in his usual place of employment, but sometimes it is more economical to send him to a special school.

Certain railway companies have organised a special body of inspectors to supervise the work of the staff, to instruct them in the application of new methods, to correct mistakes and to examine employees periodically about their theoretical and practical knowledge.

Others have organised *evening classes* where employees, while continuing to carry out their daily work, can spend part of their free time in completing their general or technical instruction. The subjects taught are for example : languages, arithmetic, elements of algebra, mechanics, technology, electricity and geometry.

Other companies have organised lectures given on the spot by leading officials which take place either during working hours in which case attendance is obligatory, or after hours. Those employees who follow the lectures and those who give them are sometimes encouraged by the giving of exceptional rewards to those who obtain the best results.

For such lectures, given on the spot, many companies make use of travelling instruction vans which contain all the material needed for demonstration : models of stations with their signalling system, models of machines, brakes, etc.

Finally many companies have founded schools, sometimes regular institutes, where employees receive the theoretical and practical instruction required for their present duties or for the duties they will ultimately be required to cover.

Among these may be mentioned the « Ecole Supérieure du Trafic » at Lyons and the « Ecole Supérieure du Mouvement » at Dijon, of the Paris, Lyons & Mediterranean Railway; the higher schools of the French State Railways at Rouen; the Railway School of the Danish State Railway; the London & North Eastern Railway Stratford Institute in London; the Schools organised by the Underground Electric Railways Company in London; the Sidney Railway and Tramway Institute, which has a membership of 28 000 and consists of a central establishment at Sidney and 41 branches all over New South Wales; the Sahebgunge School of the East India Railway; the Madras and Southern Mahratta Railway School at Madras; the Sealdah, Chandausi Schools of the Eastern Bengal Railway; those of Bulsar and Ajmer of the Bombay, Baroda and Central India Railway; and the Schools at Atbara of the Soudan Railways.

We will now mention the different categories to which the Railway Companies concerned give a special instruction, and we will indicate as far as possible the chief points with which such instruction is concerned.

The traffic department staff generally receives particular instruction in telegraphy, signalling and traffic regulations. The lecturers have at their disposal small models of signals. Also they often have, either at the schools, or in the special vans which can be sent from station to station, telegraphy apparatus, models of signals, stations, junctions and sections of the track. Lectures can also profitably be given about the best methods to be used for train working, the working of the different apparatus in use in the stations, loading and roping of wagons, weighing, gauging, etc. For such demonstrations the cinematograph is extremely useful.

The *shunting staff* receives instruction about shunting, the verification and rectification of loads; also a very important part of the instruction which can be given them, concerns the rules they should observe to protect themselves from accidents. Here also the cinematograph is very useful to demonstrate what should and what should not be done.

On certain railway companies special

courses have been instituted for the *staff charged with the settling of claims*, as their duties require a knowledge of the many questions relating to the rates and the fundamental points of commercial law in the matter of transport. The chief questions dealt with are : condition and packing of parcels, acknowledgement on despatch, total or partial loss of goods, damages, locating, delays, deteriorations, difficulties with Customs, methods of collecting, demurrage or warehousing charges, essential principles of international transport, etc. Lantern slides can be shown on the screen so as to show the points and defects of the usual kinds of packing.

Station office employees receive instruction in accountancy.

On a great number of railways the *train staff* must assist at lectures at their place of work, or even pass a period in one of the company's schools. They are there taught the regulations and given demonstrations in signalling and the movement of trains.

This also applies to *drivers and firemen* who, besides the functioning and maintenance of the different parts of the locomotive and accessory apparatus, are taught the failures that may occur and the way to repair them. Many railway companies make use of travelling instruction vans which can travel from one depot to another for the instruction of drivers and firemen. The vans carry large scale diagrams, models of different parts of the locomotive or of different signals, small scale equipment which can be taken to bits, reduced size sections of track with signals lit up electrically and workable from a distance, etc. It is useful to describe to the staff and make comments upon the mishaps and serious accidents which have occurred on the railway and to explain the causes.

The drivers, firemen and train staff are usually periodically questioned to ascertain if they really know the rules. Those who are insufficiently instructed are withdrawn from train working.

Certain railway companies have instituted a course of instruction for *rolling stock examiners*. The theoretical instruction which is given them is completed by practical instruction in the workshops (running repairs, maintenance of the lighting and brake, etc.). This is done by practical demonstrations carried out on apparatus set aside for this purpose : apparatus showing the working of the interior parts of an axle box, carriage frame with electric light equipment, steam heating and brake; frame to demonstrate buffing, bogie frame, etc. The results should be excellent.

The instruction of the *permanent way maintenance staff* has also received the attention of many railway companies. Sometimes the gangs are periodically in turn put under the direction of an inspector charged to teach them the best methods of work, sometimes the foremen are brought together to observe the repair and maintenance work of a gang chosen among the most efficient workers and working under the direction of a higher official.

The cinematograph can also play a very useful part, making it possible to show employees the best method of carrying out their duties.

Certain companies have also organised centres of instruction where courses are given to the foremen and underforemen of the service on the fitting up of points and crossings and signals, the maintenance of the track and points, making good damage, and tool equipment, etc.

Also courses are held for the *electric department staffs* on signalling apparatus, the signal and point control apparatus, methods for locating faults, etc.; the staff charged with the lighting of the stations and outside yards are given lectures on modern methods of producing and diffusing light.

The instruction of the *office staff* has

also received the attention of a great number of railway companies where courses in accountancy, drawing, foreign languages, and general administration have been organised. These sometimes take the form of correspondence courses.

The object of the methods summarised above is to teach the staff employed the knowledge they require to enable them to carry out their duties satisfactorily. The further result is to prepare the staff for higher positions. Finally, however, we wish to state that a certain number of companies have taken special steps as regards this point and established schools for operating, traffic, etc., with the special object of facilitating the promotion of the best employees to higher posts. The instruction given in these schools is more advanced.

SECTION V.

Light Railways and Colonial Railways.

[385. (01]

QUESTION XVII.

(PENETRATION RAILWAYS) (1),

by Pierre JOURDAIN,

Special Reporter.

Question XVII was dealt with in the reports drawn up respectively by :

1. — Mr. Mellini, Engineer, Chief Inspector at the Inspection of Railways, Tramways and Motor Cars Headquarters Office, Rome, for all countries except America, the British Empire, China, Japan, Belgium, France, Holland, Portugal, Spain and their Colonies; (2)

2. — Sir Ashley Biggs, M. Inst. C. E., Late Agent (General Manager) of the Madras and Southern Mahratta Railway, India, and

Mr. C. W. Lloyd Jones, C. I. E., Agent (General Manager) of his Exhalted Highness the Nizam's Guaranteed State Railway, India, for America, the British Empire, China and Japan (3);

3. — Mr. Pierre Jourdain, Managing Director of the Secondary and the North-Eastern Railways (France), for Belgium, France, Holland, Portugal, Spain and their Colonies (4).

The last named reporter, has been requested by the International Railway Congress Association to summarise the conclusions of the three reports in order to facilitate their presentation to the Madrid Congress.

Sir Ashley Biggs and Mr. Lloyd Jones, unlike Messrs. Mellini and Jourdain, have not dealt with the question of penetration railways and that of feeder railways in all countries separately.

Their report, and this is explained by the location of the railways in the countries covered thereby, rather considers the question of penetration railways, whereas the other aspect is dealt with by implication.

If we take their conclusions and compare them with those of Mr. Mellini and with the summary prepared by the third reporter, we can arrive at the principles given below, common to all three reports.

If the builders of penetration railways ought to take into account the future traffic of the lines, this should not be their sole preoccupation : the construction of a penetration railway can be justified even when the operating profits are not sufficient to produce a reasonable return on the capital invested.

The policy of the Government concerned has to be taken into account, and the value of such a railway for the commu-

(1) Translated from the French.

(2) See *Bulletin of the Railway Congress*, November 1929 number, p. 2657.

(3) See *Bulletin of the Railway Congress*, August 1929 number, p. 1487.

(4) See *Bulletin of the Railway Congress*, December 1929 number, p. 2925.

nity may justify its construction even when it cannot be operated so as to produce a profit. The point upon which the three reporters lay stress is the necessity in the interest of the future growth of the railway system of adopting the same gauge in each colony, any exception having to be justified on the grounds of some special traffic. The use of very narrow gauges should in principle be condemned and it is desirable to use only two types of track: the standard gauge, that generally used in Europe of 1.435 m. (4 ft. 8 1/2 in.) approximately; the narrow gauge of 1 m. (3 ft. 3 3/8 in.) on the average and which varies from one colony to another from 0.95 m. (3 ft. 1 3/8 in.) to 1.06 m. (3 ft. 6 in.).

The reporters each insist on the drawbacks resulting from having two different gauges in any one particular country, on the cost due to transhipping, not only of the labour required for this operation, but also because of the additional rolling stock needed, and finally through the time lost by goods in transit resulting.

Mr. Mellini recalls to notice the recommendation of the Vth Section at the last Congress in London, in 1925 :

« From the technical and the commercial points of view, it is desirable that in neighbouring countries the main and secondary pioneer railways should adopt the same characteristics for their fixed installations and for their rolling stock. »

Sir Ashley Biggs and Mr. Lloyd Jones specially stress this question and state : « We consider that we are specially qualified to speak of the harmful effect of this policy, coming as we do from a country which contains a considerable length of railways of three different gauges. »

Their preference is given to the standard gauge as it is capable of great output and high speed — but they insist above all, like Mr. Mellini, on the need in a Colonial Empire of using one gauge.

Unfortunately the error committed in India has been repeated in other countries; it is just as serious in Africa as in Asia.

Mr. Mellini quotes the following figures from the *Universal Directory of Railway Officials*, for Africa :

Standard 1.435-m. (4 ft.-8 1/2 in.) lines, 6 950 km. (4 320 miles);

1.06-m. (3 ft.-6 in.) lines, 34 000 km. (21 130 miles);

1.00-m. (3 ft.-3 3/8 in.) lines, 13 800 km. (8 575 miles);

0.95-m. (3 ft.- 1 3/8 in.) lines, 900 km. (560 miles);

0.76-m. (2 ft.-6 in.) lines, 2 150 km. (1 340 miles);

0.61-m. (2-foot) lines, 1 600 km. (1 000 miles).

The proportion, it is true, is not the same as in India where there are 48 300 km. (30 000 miles) of 1.676 m. (5 ft.-10 in.) and 32 200 km. (20 000 miles) of metre gauge lines.

The predominence of the metre gauge over the standard gauge is much greater in Africa than in India, but obviously the African railway system is the one the development of which may be expected to be the greater.

As to whether uniformity of gauge throughout the Continent is desirable is essentially a political matter depending upon the Governments concerned, but that it should exist within the boundaries of any one colony has been amply demonstrated and it seems to me that this problem is of sufficient interest to be thoroughly investigated as soon as possible and before any new railways are built.

II. — Feeder railways in all countries.

The study of this question has led the reporters to much the same conclusions. They record the marked slowing down in the building of new secondary railways in recent years.

They consider that in future very few such railways should be built, and then only when the traffic specially justifies them. Mr. Mellini considers new railways should not be built unless the expected traffic can produce receipts of at least 50 000 lires per km. (80 000 lires per mile).

The reporters find that if the slowing down of construction is due to the cost of building being out of proportion to the traffic obtained, it is also due to the development of road motor traffic, by means of which less developed areas can be given transport without locking up so much capital : the newer method of transport too gives greater speed with equal comfort.

All, however, warn those interested against exaggeration in the matter. Mr. Mellini writes : « ...Many engineers foretell the end of the usefulness and of the necessity of many secondary railways and their inevitable disappearance as a means of public conveyance.

« A pressure in this sense is exercised with all the immense power of its means by the world wide automobile industry, which, as its almost fantastic development continues, seeks today to remove all the barriers which oppose the extension of the new method of transport in its numerous applications, and in all countries including those farthest afield and those most backward. In fact a demand is made with much insistance, that the old light railways built under conditions now considered as out of date and operated in a manner which no longer meets the needs of modern population and of the present day traffic, should be abandoned, and that in certain cases the modest although very necessary functions that have so far been carried out by these railways, should be transferred to the motor vehicle.

« As in all conflicts between divergent or definitely opposed movements which hide great financial interests, there is evidently exaggeration on both sides, and it is in the middle course that the most rational solution from the double point of view of technique and economy is to be found. »

It is much to be desired that these wise remarks be broadcast throughout all Europe. Since our reports were drawn up, the « Union des voies ferrées et des transports automobiles » at the technical meeting held in Algiers, in January 1930, discussed this question very fully, Mr. Mellini taking part in the discussion as a foreign delegate. The conclusions of this discussion can be summed up as follows :

Undoubtedly there has been a mania during recent years for substituting road motor services for railway services. It is obvious that on certain light railways the traffic is insufficient to justify their maintenance; in France, for example, there are lines on which the receipts today do not amount to 5 000 fr. per km., that is to say 1 000 gold-francs (1 600 gold-fr. per mile) with a daily goods traffic hardly exceeding some ten tons. There are lines on which the figures are even lower. Such lines ought undoubtedly to be closed owing to the losses their operation entails, and road motor services substituted. On other systems, however, with much greater traffic, a method has been introduced, at the instigation moreover of road transport undertakings, under which the track is maintained but the passenger services superseded by road motor services running over the roads paralleling the railway. If we ignore certain special cases, this method, if it should come to be generally used, is technically a serious departure from the correct procedure. At a matter of fact the cost per kilometre of the road motor omnibus is equal to that of a rail motor coach of double the capacity, this statement being completely substantiated by the full information supplied by the operators. If the line with the cost of maintenance it involves be retained, it is not easy to see what benefit will be obtained

in operating a road service in substitution of a rail service, except in, as stated above, certain special cases such as an unsatisfactory location of the railway, resulting in places near the railway being badly served, or a bad profile or longitudinal section making it necessary to run at too low speeds (we are not dealing here with the case of lines of general utility on which the saving obtained by suppressing the train-kilometres largely exceeds the cost of road motor kilometres.

Outside such special cases, the simple substitution of road motor vehicles for trains cannot produce any appreciable real saving, and is not to be advised as a definite solution.

* * *

In order to combat road motor competition we should, on the contrary, increase the speed and frequency of trains by developing the use of rail motor coaches, or by electrification. In the case of lines having heavy traffic, we should consider the conversion of narrow gauge lines to standard gauge so as to abolish all transhipment — the use of heavier rails so that the speed and weight of trains can be increased — the extension of through rates with the main line companies — the use of containers. Finally we should endeavour to take over or control the feeder or competing road motor services, in order to stop the costly competition and the useless dispersion of energy, activity and capital resulting therefrom.

* * *

In brief, in order to remedy the present position of the feeder railways, the line of action should lead us to :

1. Close down those lines the receipts of which are insufficient and result in considerable operating deficit, and replace them by road motor service.

2. Improve the operating conditions of the other lines by following the guiding lines given above.

3. Take over or control the road motor services acting as feeders to or competing with the light railways.

If on their part the Governments would leave the light railways free to apply the tariffs the public could pay without adversely affecting the traffic and would regulate the road motor services, the light railways would, as a result of these concerted measures, recover from the present difficult position in which many of them find themselves and would be able to render the service expected of them originally.

[625. 614]

QUESTION XVIII.

(IMPROVEMENTS IN THE PERMANENT WAY EQUIPMENT OF LIGHT RAILWAYS) (1),

By MOSTAFA BEY HAMDI EL KATTAN,

Special Reporter.

The object of the present report is to sum up the individual reports presented on the improvements in the permanent way equipment of light railways.

These reports, two in number, are :

1. That on European Light Railways presented by Mr. Ed. VAN NOORBEECK, Director of Ways & Works of the Belgian National Light Railway Company (2), and

2. That I drew up for all countries other than Europe (3).

Fifty nine Companies replied to the questionnaire sent out by the reporters and from these the following facts may be taken.

Gauge of lines.

10 companies use the 1.435-m. (4 ft.-8 1/2 in.) gauge;

24 companies use the 1.067-m. (3 ft.-6 in.) gauge;

12 companies use the 1.00-m. (3 ft.-3 3/8 in.) gauge;

1 company uses the 0.90-m. (2 ft.-11 1/2 in.) gauge;

9 companies use the 0.75-m. (2 ft.-5 1/2 in.) gauge;

5 companies use the 0.60-m. (1 ft.-11 5/8 in.) gauge.

Traction.

41 companies operate their lines entirely by steam;

13 companies operate their lines by both steam and electricity;

6 companies in addition to steam and electric operation also use petrol and motor vehicles.

The weight of locomotives continues to increase; for example some companies on which the maximum axle load was originally 19.5 t. (19.2 English tons), now allow 32 t. (31.5 Engl. tons), and on others the weight of the locomotive which was 89 t. (87.6 Engl. tons), is now 138 t. (135.8 Engl. tons).

Ballast.

The use of ballast has become general; the depth varies from 0.15 to 0.20 m. (6 to 8 inches).

A large number of companies, to make it easier to inspect sleepers and fastenings, leave the sleepers uncovered, whereas others keep the rails and fastenings clear, but keep the sleepers covered. This latter method, especially in hot countries, has the good feature of preventing wood sleepers from splitting.

Rails.

Except for 4 companies still using bull headed rails, Vignoles rails weighing from 7 kgr. to 46 kgr. per m. (14.1 to 92.7 lb. per yard) are used.

(1) Translated from the French.

(2) See *Bulletin of the Railway Congress*, October 1929 number, p. 2149.

(3) See *Bulletin of the Railway Congress*, September 1929 number, p. 1941.

This great variation in weight naturally results from the amount and nature of the traffic, the weight of the rolling stock used, and the system of traction employed.

The length of rail varies between 6 and 18 m. (19 ft. 8 1/4 in. and 59 ft. 5/8 in.). Some companies, in order to reduce the number of joints, the weakest point in the track, weld the joints over a more or less great length. The *Société des Transports en Commun de la Région Parisienne,* for example, states that in the case of its lines laid alongside roads, thanks to the ballast being almost level with the top of the rails, it has been possible to weld by the thermit process lengths up to as much as 200 m. (656 feet).

No special expansion device has had to be provided at the ends of the rails, nor has any difficulty been experienced.

The *Belgian National Light Railway Company* is also welding rails into 60-m. (197-foot) lengths as ordinary practice, and have made trial lengths of 72 m. (236 feet) without any apparent drawbacks.

Interesting details on the various welding methods as upon the expansion of rails are given in the report by Mr. Van Noorbeeck on pages 2160 to 2164 of the October 1929 *Bulletin of the Railway Congress.*

The general practice is for the rails to be held down on the sleepers by coach screws. Only four companies still use the gib fastening.

As regards sole plates (always of metal) several companies have given up their use and lay the rails directly on the sleepers.

Tests made by the *Belgian National Light Railway Company* have shown that track laid without sole plates stands up well on straight sections, but on curves the coach screws tend to pull out and bend.

Sleepers.

All the companies replying to the questionnaire use sleepers; 33 use only wood sleepers alone; 7 use metal sleepers exclusively; 5 use both wood and metal sleepers; 1 uses at once wood, metal, and reinforced concrete sleepers, and 3 use wood and reinforced concrete sleepers.

The spacing of the sleepers on open lines varies between 0.75 and 0.80 m. (2 ft. 5 1/2 in. and 2 ft. 7 1/2 in.). This spacing is reduced to 0.45 to 0.50 m. (1 ft. 5 11/16 in. to 1 ft. 7 11/16.) for the joint sleepers.

For wood sleepers, creosoted oak or pine is most used.

The type and weight of metal sleepers varies for each company. In France, the *Union des voies ferrées et d'intérêt local* has designed a metal sleeper in two patterns either of which can be used for standard gauge or for metre gauge track, and which is widely used.

On pages 2168 and 2169 of the October 1929 *Bulletin,* drawings of these sleepers as well as the one used on the Swiss Rhætian Railway, will be found.

Reinforced concrete sleepers have been used for a number of years, but have not yet come into general use.

Several types of such sleepers are being used and very interesting information on reinforced concrete sleepers generally, will be found on pages 2170 to 2181 in the October 1929 number of the *Bulletin.*

Points and crossings.

Most of the companies build up their points and crossings from their ordinary rails, machined as required and assembled by bolts.

In recent years however, special manganese steel has been used for the frogs.

The *Société des Transports en Commun de la Région Parisienne* and the *Belgian National Light Railway Company* are using on a large scale, points and

crossings of manganese steel, and the results have been entirely satisfactory.

The manganese content can vary between 10 and 14 %, the carbon being about 1 %.

In America cast nickel-chrome steel is now being used for crossings. The steel is a complex alloy containing 2.75 % of nickel, 0.80 % of chrome, and 0.50 % carbon, giving a breaking strength of 75 kgr. per mm² (47.6 Engl. tons per sq. inch), with 12 % elongation. The metal is easy to machine and can be welded by the alumino-thermic process without appreciable change in its resistance to wear, a quality manganese steel lacks.

Particulars of the tests made by the *Belgian Light Railway Company* with cast chrome-nickel steel are to be found on pages 2184-2188 of the October 1929 *Bulletin.*

Signals.

On most of the light railways outside Europe, there is no system of signalling properly speaking. Several companies use red and green flags during the day, and lights giving the same colours during the night. Other companies are satisfied to use discs as advance or warning signals.

Three companies alone use the absolute block.

In the September 1929 *Bulletin of the Association,* will be found a table taken from my report on Question XVIII in which is given a summary of the replies received from the various companies.

Maintenance of the track and rolling stock.

The replies from the Light Railway Companies outside Europe, show that no improvements have been introduced into the methods used in maintaining the track and the rolling stock. In the final table of my report, all details relative thereto will be found (September 1929 number of the *Bulletin of the Railway Congress).*

Finally, I cannot do better than give *in extenso* the summary made by Mr. Van Noorbeeck in his own report, the text of which is as follows :

« Axle loads of the stock is increasing more and more, necessitating well made, dry, and well drained earthworks, and a much stronger and more solid permanent way.

« Any gauge of track can be suitable according to local circumstances.

« Equally, the choice of traction is a matter of convenience.

« The Vignoles rail which is almost exclusively used in the lines laid beside high roads or on special earthworks, has the following average characteristics :

« Gauge of track 1.435 m. (4 ft. 8 1/2 in.): height 140 mm. (5 1/2 inches); width 130 mm. (5 1/8 inches); head 60 mm. (2 3/8 inches), of an average linear weight of 38 kgr. (76.6 lb. per yard). Metre gauge : height 113 mm. (4 7/16 inches); width 90 mm. (3 1/2 inches); head 45 mm. (1 3/4 inches), of an average linear weight of 23 kgr. (46.4 lb. per yard) for the lines worked by steam; and of 125 mm. (5 inches) height, 105 mm. (4 1/8 inches) width, 57 mm. (2 1/4 inches) head, of an average linear weight of 32 kgr. (64.5 lb. per yard) for those worked electrically.

« The length of the rails varies generally between 9 and 18 m. (29 ft. 6 3/8 in. and 59 ft. 5/8 in.) with a tendency towards the latter figure.

« There is a marked preference for leaving the top of the sleepers free from ballast in view of the easier inspection and maintenance of the rail fastenings.

« The choice of the kind of ballast is chiefly guided by economic reasons, although it is recognized that broken stone constitutes the best ballast.

« Corrugated wear of rails only shows itself to a small extent on light railways. The remedy for this trouble can be found in the use of a good and homogeneous

steel with a high tensile strength, a high elastic limit and the highest possible elongation. These different characteristics must be in suitable proportions to each other.

« The laying of the track is done with opposite joints on the straight, staggered joints being used only when laying in curves of a radius generally smaller than 100 m. (5 chains).

« Creep is hardly apparent in light railways. It is overcome either by the fixing of angle fishplates to the sleepers, or by stirrups which are fixed to the rails and the sleepers, or simply by stirrups against the heads of the coach-screws.

« Frequently, the rails are laid at an inclination on the sleepers. This cant is obtained either by adzing the sleepers or by the shape of the sole plate or the chair.

« The first mentioned system is, however, the more generally used.

« The fishplates of the rails are becoming simpler and generalized by the angle fishplate with four or six bolts; the loosening of these is chiefly prevented by spring washers, Grover type, or by tension plates.

« Grooved or twin rails are used on the inner line of curves of a small radius. In this case the use in the outer line, of rails made of high tensile steel or special steels (manganese and chrome-nickel) is recommended.

« Barberot keys can be used with economy on the outer rails of small curves.

« The use of sleepers is general. Sleepers of oak, or pine impregnated with creosote, are the most used.

« The rails are fastened to the wooden sleepers by means of coachscrews either direct or in conjunction with steel sole plates, without marked preference for either system.

« When metal sleepers or ferro-concrete sleepers are used, the fastening of the rail is usually by means of clips and bolts.

« The metal sleeper has advantages as regards duration and the security of the fastenings; it is not however extensively used.

« Concrete sleepers are being increasingly used, although they are costly and rather difficult to handle. The type consisting of two supports with large bearing surface joined by a small metal tie bar or by a ferro-concrete bar is generally preferred. It gives very encouraging results.

« The welding of rails is not yet general practice.

« Experiments made on a large-scale and of long duration show, however, the considerable advantages which can be obtained therefrom and encourage the development of its use.

« Thermit welding has up to now only been employed for new lines, are welding for old rails, repairs to points and crossings and building up of rail ends.

« The process generally adopted when electrically welding rails consists in welding the fishplates to the rails, to stiffen up the joint by a plate welded under the foot and to weld the heads of the rails together.

« Electric welding of the rails end to end without fishplates is, however, developing, and it would be interesting to see it continued in view of the encouraging results obtained during the experiments.

« The limit, as regards length, of the parts of the line to be welded on special site or beside high roads is a matter of the temperature fluctuations in the district. For a temperature fluctuation of 60° C. (108° F.) the welded length can go up to 60 m. (197 feet) without inconvenience.

« The use of treated cast steel in the manufacture of crossings is developing and gives very satisfactory results.

« The experiments with special manganese or chrome-nickel steel for the manufacture of parts subjected to much strain (crossings and cross-overs) have given entire satisfaction from the economic point of view as well as from that of wear. »

[621. 33]

QUESTION XIX.

(ELECTRIFICATION OF SECONDARY LINES) (1),

by L. SEKUTOWICZ,
Special Reporter.

Question XIX, *Electrification of secondary railways*, has been the subject of two reports, compiled in a very different spirit.

Messrs. Eugenio RIVERA, Inspector General of Roads and Bridges of Spain, General Manager of the Tangiers-Fez Railway, and José GARCIA-LOMAS, Engineer of Roads and Bridges, attached to the Headquarters of the North of Spain Railway, had to study all countries outside Europe,

and Mr. L. SEKUTOWICZ, Director of the Omnium Lyonnais (Paris), the countries of Europe.

The Reporters agreed upon the text of the questionnaire (2) sent to 133 European Companies and 92 Administrations outside Europe.

Of these 225 members of our Association, 108 sent replies but only 7, including 5 European administrations, have provided useful information. This sort of failure is due to the fact that most of the electrified secondary lines, which are not yet very numerous, belong in general to administrations which are more often than not affiliated to Light Railway Unions. Apart from rare exceptions, the trunk railways do not operate any electrified *secondary* lines.

As a consequence, the Spanish reporters have examined all the documents which have appeared, supplemented by personal enquiry, and have presented a remarkable report (3) on the question of public transportation, especially in new countries, and excluding trunk systems (electric lines and steam lines, rail motor vehicles, the part played by road transport, etc.). It is impossible to condense this very vivid report. It gives a very interesting idea on what has been done outside Europe. The writer will endeavour to summarise the portion relating to electrified secondary lines properly so called and the conclusions of the authors, referring his colleagues to the paper itself for the rest.

The French reporter, on the contrary, has in the first place examined the problem rather in a theoretical sort of way (4) and has restricted himself to a description of several applications selected from among the most interesting of the European administrations who have replied to the questionnaire. In addition, he has turned his attention to the economic aspect of the problem, which is, moreover, the most difficult.

The authors emphasise the difficulty of giving a *definition* of *secondary railway lines*. Such lines cannot, in fact, be differentiated either by the gauge, the intensity of the traffic or even by the

(1) Translated from the French.

(2) This text was reproduced at the end of the report drawn up by Messrs. Rivera and Garcia-Lomas. Secondary railways were defined therein as follows : « By secondary railways should be understood those railways of which the normal or narrow gauge lines, while forming part of the general system, connect less important centres, and of which the characteristic features of engine stock, general construction, speeds and traffic are inferior to those of the main railways. »

(3) See *Bulletin of the Railway Congress*, February 1930 number, p. 665.

(4) See *Bulletin of the Railway Congress*, February 1930 number, p. 491.

features of their equipment and operation alone. Moreover, railways of local interest ought not generally to be confused with secondary railways.

Nevertheless, the latter are usually distinguished from public railways by a less considerable traffic, less powerful material, and a more difficult location. The financial resources of the Companies operating them are less, and the profits are often very small or even negative. All these causes make the financial problem set by electrification more acute, as the reporters point out from the outset.

The characteristic feature of electric traction is that is requires a considerable locking up of capital resulting in *financial charges*, which have to be made good by savings in the *operating costs*. The smaller the traffic, therefore, the more difficult it is to ensure financial equilibrium. One may even say that it can be realised but rarely when the line to be electrified is one already in existence, the rolling stock of which has not paid for itself or cannot be utilised elsewhere. This equilibrium may be realised, starting from a certain minimum traffic, when the line has yet to be constructed. In difficult country, especially in the colonies, some of the expenses of the electric equipment may be saved on the cost of the permanent way.

In general, however, it will only be possible to adopt electric traction in special cases, especially in mountainous country, or in order to utilise and facilitate a regional distribution of power, to save coal, to satisfy certain demands of national defence, or again, in order to meet the competition of motor transport, to serve a region where water and fuel are scarce, and finally in exceptional cases, to provide a very frequent service between two towns, etc.

Advantages of electric traction.

In his report, Mr. Sekutowicz discusses in the first place the *advantages*, especially the technical advantages, of electric traction on secondary lines, and their effect in reducing the working expenses. After indicating the chief systems (monophase at 6 000 to 10 000 volts — D. C. at 1 200 — 1 500 — 3 000 volts — use of accumulators), the reporter points out that, in their present technical state, the two systems first mentioned are substantially equivalent, and that the selection to be made between them depends oftenest upon the type and source of the power available. As regards accumulators, their use in the present state of technical practice is exceedingly limited, and can only be considered on lines almost without gradients.

In France and in the French colonies, the electrification of certain lines has been very happily combined with the distribution of power at high tension in wide areas. As thus understood, the problem naturally leads to the adoption of direct current at high tension, preferably at 3 000 volts, obtained by means of sub-stations with mercury vapour rectifiers and a three-phase distribution at 50 cycles per second, a frequency which is unsuitable for traction by monophase current, but which is essential for other uses. The latter always predominate over traction, even when trunk lines are electrified.

Standardisation of equipment.

Mr. Sekutowicz goes on to point out the *importance of a reasonable standardisation of equipment*. This importance is also brought out on reading the report of our Spanish Colleagues, showing in particular the variations in the gauges used in different countries : 0.60 m. - 0.61 m. - 0.75 - 0.80 m. - 1.00 m. - 1.067 m. - 1.44 m. - 1.676 m. (1 ft. 11 5/8 in. - 2 feet - 2 ft. 5 1/2 in. - 2 ft. 7 1/2 in. - 3 ft. 3 3/8 in. - 3 feet - 4 ft. 8 1/2 in. - 5 ft. 6 in.).

Gauges of 1.00 m. (3 ft. 3 3/8 in.) and 1.067 m. (3 ft. 6 in.) are by far the commonest and enable all the requirements of secondary lines to be met. Moreover

such lines, when they are direct feeders, are often of the same gauge as the main lines of that particular country.

Possibility of adopting electric traction (economic point of view).

The second part of the French report is devoted to an examination of the *conditions governing the possibility of adopting electric traction* on secondary lines, a distinction being drawn between the case of a new line and that of a line already in existence, based upon an economic standpoint. Electrification always results in a saving in coal, even when thermal power only is available (1).

A comparison between the saving in fuel which may be effected, and the financial burdens of electrification, shows that in the case of light trains, and only taking into account the saving in fuel (which neglects, *inter alia*, the saving in personnel), electrification only pays *as regards a new line* provided at least a certain number of trains are run daily (12 pairs of trains, for example). On an *existing line* the possibility depends upon the rate of interest on the capital involved, and cannot always be realised. In every case, the decisive factors of the problem are the rate of interest and the frequency of the service still more than the intensity of the annual traffic per mile.

Description of several applications.

After this discussion of a necessarily theoretical character, because in such a matter, a strict opinion can only be given in each particular case, the reporter proceeds with the *examination of a certain number of applications,* an examination which also forms the greater part of the report of Messrs. Rivera and Garcia Lomas.

It is a remarkable fact that the last-mentioned report only refers to a few heavy traffic lines equipped for monophase current, and almost exclusively located in the U.S.A. All the other applications relate to continuous current at high tension (1 200 to 1 500 volts and 3 000 volts). Moreover, monophase current adopted exclusively for their main lines by Sweden, Germany, Austria and Switzerland is less employed in the U.S.A. than continuous current (1).

It would be interesting, before passing on to a review of the different countries, to give, by means of figures taken from official statistics, some idea of the total length of the secondary lines and of that of the electrified lines, and to supplement these data by figures giving the intensity of the traffic, the cost of installations, etc... A certain number of statistics of this type will be found in the two reports, but it is not possible to condense them into one joint table.

(1) The discussion is based on the relationship λ between the coal consumption c in kilogrammes and the power consumption N in kilowatt-hours per tonne-kilometre hauled.

We have $$\lambda = 1\,350 \frac{\rho_e}{\rho_v} c$$

wherein ρ_e is the annual mean efficiency of the plant between the point where the purchased power is measured and the axle of the driving wheels, and ρ_v is the « mechanical » efficiency of the steam locomotive, of which the coal consumption c per indicated horse power is of the order of 1.350 kgr. (3 lb). (In practice, ρ_e is in the neighbourhood of 0.85 and ρ_v of 0.78, but the value of λ, in the neighbourhood of 2, calculated in this way ought to be increased to take into account parasitic consumptions, λ thus increasing to 3 or 4.)

(1) Messrs. Rivera and Garcia Lomas give the following figures for the U.S.A. of 21 electrified public trunk lines or systems: only 8 lines with a total length of 700 km (435 miles) are equipped for monophase current, as against 8 with a length of 751 kilometres (467 miles) equipped for low tension continuous current (575 to 650 volts) and 5 with a total length of 1 158 km. (962 miles) equipped for high tension continuous current (1 200 to 3 000 volts). The extensions are continued by using the systems adopted at the start, but new installations are most frequently laid down for continuous current at 3 000 volts.

It will be mentioned merely that, in 1925,

France possessed 22 600 km. (14 040 miles) of secondary lines, 1 069 km. (664 miles) of which were equipped with electric traction.

Germany, in 1914, 10 700 km. (6 650 miles) of secondary lines;

Italy, in 1924, 5 000 km. (3 100 miles) of secondary lines, 889 km. (552 miles) of which were equipped with electric traction;

Belgium, in 1925, 4 500 km. (2 800 miles) of secondary lines, 432 km. (268 miles) of which were equipped with electric traction;

Switzerland, in 1920, 2 000 km. (1 240 miles) of secondary lines, 1 300 km. (808 miles) of which were equipped with electric traction;

Poland, in 1922, 2 767 km. (1 720 miles) of secondary lines, 205 km. (127 miles) of which were equipped with electric traction.

These figures show the relatively insignificant development of electric traction, except in Switzerland, which is explained by the causes of an economic nature referred to above.

In Europe, monophase current is employed on a fairly large scale by the secondary railways, especially in France. One of the most characteristic applications, details of which are described in Report No. 1 is that of the *Rhætian Railway* [277 km. (172 miles), 1 m. (3 ft. 3 3/8 in.) gauge, mountainous line, long tunnels)].

The traffic comprises, on the average, 15 pairs of trains daily. The bogie locomotives, type I-B-I, I-D-I and C+C weigh 37 to 68 tons and haul trains of 150 to 250 tons. The line is fed with monophase current at 1 000 volts and 16.6 cycles per second.

The Rhætian Railway is a true secondary railway, assuring an important service in a Swiss region of great interest from the touristic point of view.

The metre gauge system of the *Camargue Railway* is on the contrary the type of small local railway fed directly with monophase 25-cycle current from a three-phase network.

In Europe, *high tension continuous current* also is used in numerous applications : as an example of lines with very little traffic, one may quote the Vicinal Railways (Jura) using D.C. at 1 500 volts. The North of Milan Railway (D.C., 3 000 volts, utilising rail motor vehicles, etc.) is likewise described in report No. 1 as possessing a comparatively intense suburban traffic.

In the *countries outside Europe*, this mode of traction is almost exclusively adopted at the present time, as shown by the following extracts from the report of Messrs. Rivera and Garcia Lomas.

Japan possesses 200 private companies of a secondary or local character with 5 000 *km.* (3 105 miles) of lines, of which 1 000 *km.* (621 miles) are electrified (partly with mixed traction). There are 132 electric locomotives and 948 rail motor vehicles.

In general, the gauge is 1.067 m. (3 ft. 6 in.) and the traffic is intense. Gradients of more than 3.3 % are only allowed exceptionally, and there are none greater than 8 %. The locomotives, generally of 18 to 50 tons and 60 to 1 000 H.P., have usually 4 motors and the majority are built in Japan. The report contains interesting figures of the cost of the equipment and the running expenses (1).

In *Korea*, out of 2 000 km (1 240 miles) of 1.067-m. (3 ft. 6 in.) gauge secondary lines, 116 km. (72 miles) are electrified with D. C. at 1 500 volts. In *Manchuria*, the main system, of standard gauge, of 1 120 km. (696 miles) is electrified over 40 km. (25 miles) with D. C. at 1 200 volts. There is no electrified secondary

(1) Japan also has in view the electrification at 1 200 and 1 500 volts D.C. of about 800 km. (500 miles) of trunk lines.

line. In *China*, the electrification of the suburban railways of Shanghai is projected. In *Siam*, a line of 1-m. (3 ft. 3 3/8 in.) gauge is equipped with electric traction.

In *Indo-China*, out of 200 km. (124 miles) of secondary lines, the suburban lines of Hanoi alone are electrified.

In *India*, where the traffic is considerable and where the railways are in full development, 550 km. (342 miles) of main lines are electrified or are being equipped (D. C., 1 500 volts), but all the secondary lines are steam operated.

In *Java*, where the railways are very developed, a section only of 120 km. (75 miles) of a *main line* with intense traffic is in course of electrification with D. C. at 1 500 volts produced by water power.

Africa is as yet rather poor in railways. The *Union of South Africa* has electrified about 400 km. (250 miles) of line of a main artery (D. C. at 3 000 volts) and the Capetown suburban lines (83 km. [52 miles] D. C. at 1 500 volts).

In *Egypt*, the electrification of a section with intense traffic in the suburbs of Cairo only is projected. *Rhodesia*, the *Egyptian Sudan* and *Nigera* do not yet employ electric traction.

In the *Belgian Congo*, electrification with current produced by water power is projected on a section of the Matadi-Kinshasha line with intense traffic.

Among the French Colonies in Africa, *Algiers-Tunis* possesses no secondary line having electric traction, but in *Morocco*, the gradual electrification of the country has been decided upon, with a view of utilising the water falls situated south of the Grand Atlas Mountains, that of Oum-er-Rebia at Sidi Machon being the first (26 000 kw.). Three thermal power stations constructed at Casablanca and Salé will also feed a 60 000-volt network, which already distributes 40 million kw.-h, 1/4 of which is for the railways. The latter are equipped for D. C. at 3 000 volts with locomotives (B+B) of 1 000 H. P. and rail motor vehicles, over a length of 238 km. (148 miles) which will be later increased to 1 100 km. (683.5 miles). The goods traffic is important.

In *French West Africa*, it is intended to utilise the falls of Jonina on the Senegal in order to electrify the Kayes-Niger line, the gradients of which attain 1 in 33 and which has just been connected to the Kayes-Thiès line, whose maximum traffic exceeds 76 trains daily, 50 of which are goods trains.

In *Madagascar*, electrification of the Tamatave-Tananarive line by means of the falls of the Nangoro is being examined, and electrification of a section of 64 km. (40 miles) of the line Tananarive-East Coast has been approved.

In *America*, *Canada* possesses three short electrified sections of main line and various small old inter-urban lines. The competition of road motor transport is very serious in this country.

In the *United States*, the electrified lines are very important and very few have the character of secondary lines. The reporters quote, however, the *Boston Revere Beach and Ligne Railroad* (55 km. [34.2 miles]), 21 [13 miles] of which are double track, which has been rescued from competition by equipping it with D. C. at 600 volts, and some lines of the *Reading Company*, which are going to be electrified with the same object. The *Fonda, Johnston and Gloversville Ry. Co.* are operating a normal gauge line of 53 km. (33 miles) with a branch line of 16 km. (10 miles) serving as a feeder for the *New-York Central* in the suburbs of Schenectady — D. C., 550 volts). The *River Lumber Co.* are operating a line of 28 km. (17.4 miles) with D. C. at 1 500 volts.

The report mentions that, owing to the competition of motor vehicles, out of 65 000 km. (40 400 miles) of urban and interurban lines with electric traction, 944 km. (587 miles) have been abandoned

altogether (1) and 952 km. (592 miles) have been partly abandoned. Of this total of 1 896 km. (1 179 miles), about 754 km. (468 miles) have been replaced by road motor services.

On the other hand, in 1928, 248 km. (154 miles) of urban railways and 84 km. (52 miles) of interurban railways were newly constructed, and 1 026 km. and 348 km. (638 and 216 miles), respectively, were reconstructed.

In order to meet the competition of automobiles, some of the companies are themselves running motor omnibus services, and others are modernising their material, lightening it and speeding up the service, and finally dispensing with one of the two train employees. A certain number of Companies are utilising, with the same object, luxury coaches driven by internal combustion engines with electric transmission.

These coaches (some of which are multiple units and equipped with 400-H. P. engines) are now run on special fuels, obtained by distillation or cracking and which may be used in engines with ordinary carburettors. Diesel engines for burning heavy oil directly are also used.

In *Mexico*, one of the main lines is being electrified over a length of 103 km. (64 miles) with D. C. at 3 000 volts and locomotives of 2 700 H. P.; a small line of 25 km. (15.5 miles) and 0.76-m. (2 ft. 6 in.) gauge, with a goods service, is also being electrified (D. C., 600 v.).

In *Cuba*, 124 km. (77 miles) of suburban lines of Havana, with intense traffic, are equipped with D. C. at 600 volts and the Hershey Cuban Railway is electrified over 138 km. (86 miles) with a thermal power station of 7 500 K.-V.-A. Distribution is effected at 35 000 volts, with locomotives and rail motor vehicles fed with D. C. at 1 200 volts.

In *Guatemala*, a line of 45 km. (28 miles) of secondary character with gradients of 1 in 11 is fed with D. C. at 1 500 volts, the current being produced by water power.

In *Costa Rica*, a main line of 129 km. (80 miles) is being equipped with single phase current at 20 cycles and 15 000 volts.

In *South America*, there is an incredible variety of railways among which the lines of secondary character are difficult to distinguish.

The *Argentine* has electrified the suburban railways of Buenos Ayres, where the traffic is intense (D. C. at 800 volts, 3rd rail).

In *Brazil*, the *Paulista* Company has electrified with real success its main line of 1.60-m. (5 ft.-3 in.) gauge over 286 km. (178 miles) with D. C. at 3 000 volts and powerful and fast locomotives.

The *Western of Minas* Railway, gauge 0.60 m. (1 ft. 11 5/8 in.) is electrified with D. C. over a distance of 73 km. (45.4 miles).

In *Chili*, 232 km. (144 miles) of trunk lines are equipped with D. C. at 3 000 volts with powerful and fast locomotives. The same applies to the Chilian section of the Trans-Andean Railway (71 km + 179 km. [43.8 + 111 miles]), partly of metre gauge, which may thus assure a service all the year round. (The crossing is made at an altitude of 3 190 m. (10 460 feet). There are only two trains daily, plus two trains a week (D. C., 3 000 volts, traction by adhesion and by rack).

Finally, 3 small industrial lines are equipped electrically.

In *Venezuela*, a line of 37 km. (23 miles) has been equipped with D. C. at 1 500 volts to meet road competition.

In *Oceania*, where all gauges of track with many transhipments are met with (in Australia), electrification is restricted at present to the suburban lines of Sydney and Melbourne (D. C., 1 500 volts).

In *New Zealand*, a section of 13.5 km. (8.4 miles), with steep gradients, of a

(1) They belong to 27 Companies, 10 of which are electric traction Companies.

main line is electrified with D. C. at 1 500 volts.

General considerations on the above applications.

In brief, the application of electric traction is still rare and limited to particular cases on account of its high cost, when material which is still capable of being used has to be discarded. It is only when cheap electric power is available, when coal is dear, the water of poor quality and the line is difficult, that its adoption may be considered. It is the new lines, however, which are chiefly destined to profit most by it. The system which is in the greatest favour at the present time is that using D. C. at 1 500 to 3 000 volts. In many cases it enables the passenger trains to be increased sufficiently in numbers in order to meet the competition of road motor vehicles, which steam locomotives are no longer able to do.

Accumulator rail motor vehicles and rail motor vehicles driven by internal combustion engines, with or without electric transmission.

These conclusions have induced our Spanish colleagues to examine the various systems of rail motor vehicles, capable of ensuring these services, without requiring the heavy immobilisation of capital necessitated by equipping the lines electrically. They examine in turn :

Rail motor vehicles driven by petrol or steam engines or by electric accumulators, and finally vehicles with electric transmission of the power developed by an internal combustion engine (petrol paraffin — heavy oil).

It is impossible to summarise here the interesting data collected by the authors on this subject, which would lead us away from the problem as set. It may be mentioned merely that, as regards the use of accumulators, the *Compagnie des Chemins de fer des Charentes* has put into service in France 6 accumulator rail motor coaches, having 32 places and weighing 14 tons, capable of pulling two 5-ton coaches (radius of operation without recharging 150 km. (93.2 miles). Power, 108 H. P. Speed on the level, 47 km. (29.2 miles). Iron-nickel battery. The constructors maintain the battery for an annual sum of 12 % of the cost price, which represents 0.40 fr. per train-km. (0.648 fr. per train mile) and the running expenses are not very high, the power (purchased at 0.16 fr. the kw.-h. during the night hours) costing but 0.50 fr. per motor coach-kilometre (0.81 fr. per motor coach mile). The price of these coaches is 350 000 francs.

The French report, on the other hand, gives the results obtained in Italy with light accumulator rail motor coaches. Apart from the applications made in Germany to train services and tramways effected by means of heavy accumulator motor coaches, various large Companies have employed accumulators for driving shunting locomotives.

The *Chicago North Shore*, for certain goods services, employs 65-ton, 800-H. P. accumulator locomotives.

The *New York Central Railroad* likewise employs 115-ton, 1 600-H. P. shunting locomotives, the accumulators of which are charged by a 300-H.P. Diesel set.

The *Chicago and North Western Railway* possesses a 118-ton accumulator locomotive, which would be capable of pulling a train of 2 000 tons for 26 km. (16.1 miles) without recharging.

Finally, the reporters emphasise the importance of vehicles provided with *internal combustion engines*, which utilise *electric transmission*, the cost of which is no longer prohibitive when the power exceeds 150 to 200 H. P. This system provides incomparable flexibility in driving and running.

The figures quoted in the report are very favourable to this type of vehicle, which enables competition to be met, at

least as regards passenger traffic, and assures the service in the shunting yards of the important lines by suppressing the useless consumption while standing, which prejudices so seriously the cost of steam traction.

CONCLUSIONS.

The two reports lead to the same conclusions, which may be summarised as follows :

1. From the technical point of view, the railway operators have merely to make their selection, monophase current and high tension continuous current with overhead equipment having demonstrated their suitability whilst the principal firms supply perfectly satisfactory equipment.

2. Electrification of the main lines, and that of large areas by utilising natural motive forces and the recent improvements in mercury vapour rectifiers have facilitated the use of electric traction, particularly in the case of high tension continuous current, which has been made possible by the use of motors with commutating poles.

3. From the economical standpoint, however, electrification is mostly only possible in the case of *new* lines, which also possess features favourable to the system (cheap current, dear coal, sufficiently heavy passenger traffic, difficult lines, necessity of meeting competition).

4. Nevertheless, especially in new countries, the general interest may lead to the adoption of solutions which are not fully justified from the point of view of the return for invested capital, but necessary for the development of the country. In this case, it may be of interest for the community to cover the expenses of electrification out of the national or provincial budgets, so that the burden of those expenses will then in part fall upon the tax payers, and not on the users alone. This, moreover, is the case with roads, canals, etc.

5. « Complete » electrification of secondary lines, including in this term the electrification of the rolling stock and the construction of the power supply system is only possible, therefore, from the economic point of view, with the proviso mentioned above, namely, in countries or regions where electric power is distributed on a wide scale and may be obtained under exceptionally advantageous conditions, such conditions being promoted by the growth of the population and the corresponding increase in the passenger traffic.

6. In the case where special systems are employed for certain traffic, especially the passenger traffic, it is possible with the Spanish reporters, to call « incomplete » electrification the electrification alone of the motive material, carried into effect either by producing the necessary electric energy in rail motor vehicles (Diesel-electric or gas-electric motor vehicles) or by accumulating the energy taken from an external source (traction by means of accumulators). This solution is interesting for those railways, both secondary and principal, which serve sparsely populated districts, or which are in competition with other modes of transport. Such is the case when the investment of considerable capital in « complete » electrification is not justified by the density of the passenger traffic or by the saving which might be effected by substituting electric traction for steam traction, as regards passenger traffic, or even goods traffic.

[621. 132.8]

QUESTION XX.

(RAIL MOTOR COACHES) (1),

By Paul BEGHIN,
Special Reporter.

Three reports have been drawn up on this question :

1. By Messrs. C. E. Brooks, Chief of Motive Power, Canadian National Railways and R. G. Gage, Chief Electrical Engineer, Canadian National Railways (2);
2. By Mr. Z. Zavadjil, Engineer, Chief of the Locomotive Department at the Headquarters of the Yugoslav State Railways (3);
3. By Mr. Paul Beghin, Manager of the « Compagnie de Chemins de fer Départementaux », Paris (4).

* * *

I. — *Report by Messrs. BROOKS and GAGE (all countries, except Europe).*

The reporter first of all dealt with the historical aspect of the question. At the beginning of the 20th century, it was recognised that a light rail motor coach inexpensive to run could be used advantageously for certain classes of traffic.

The steam propelled vehicle was used in England, the petrol engined vehicle in the United States, and the Diesel motor coach in Sweden.

The need for such vehicles made itself especially felt after the war. First of all, light vehicles on two bogies with a 100-H. P. motor with mechanical transmission were used, the vehicles providing 50 seats and weighing 36 tons.

Larger vehicles were then built with 250-H. P. motors, and weighing 54 tons. At this point it was realised that for powers exceeding 150 H. P., electric transmission became necessary.

In 1917, the Canadian Railways put into service accumulator vehicles having four 25-H. P. motors with a radius of action of 177 km. (110 miles) and weighing 32 tons.

During the same period, England and the British Colonies were using steam rail cars, having 130-H. P. engines and weighing over 32 tons. He points out that even if small rail motor coaches will always find employment, the tendency in the United States and Canada is to build high speed vehicles [105 km. (65 miles)] an hour with at least 300-H. P. engines which can haul one, or a number of trailers making up a train of 150 to 200 tons.

The 1214 rail motor coaches considered in the report are classified as follows :

1. — Not exceeding 150-H. P. :

83 steam 5 accumulator 413 petrol	All with mechanical transmission.

2. — Between 170 and 300 H. P. :

148 petrol with mechanical transmission,

324 petrol with electric transmission,

(1) Translated from the French.

(2) See *Bulletin of the Railway Congress*, October 1929, p. 2229.

(3) See *Bulletin of the Railway Congress*, October 1929, p. 2203.

(4) See *Bulletin of the Railway Congress*, February 1930, p. 443.

43 distillate with electric transmission,
18 Diesel with electric transmission.

3. — Above 300-H. P. :

16 distillate	All with electric transmission.
150 petrol	
2 Diesel	

a) Petrol is most widely used because of the ease with which supplies can be obtained, and the fact that drivers and fitters are available everywhere. It has some drawbacks, such as its explosibility, and the poor heat efficiency of the motor.

The report stresses the danger of explosion present through the mixture of petrol which has got past the piston rings with the lubricating oil in the crank case.

b) Distillate is used to denote an oil intermediate between petrol and a light fuel oil.

This oil is burnt in a modified design of petrol engine fitted with special carburettors. Petrol is used when starting until the required running temperature is reached.

The advantage lies in the reduced risk of fire and the lower price in some countries : the disadvantages result from the reduction in efficiency as compared with petrol, of 3 to 5 %.

c) Paraffin or Diesel motors are used with great success on the Canadian National Railways on which this type has been adopted for the future.

The name of Diesel as commonly used in America means a motor in which the charge is fired by the compression temperature. This motor is not used as in Europe where the original Diesel cycle of constant pressure is employed.

Those used on the Canadian National do not work on this cycle : they are « airless high pressure injection engines ». They have the advantage of freedom from risk of fire, a low priced fuel available everywhere and a high thermic efficiency.

The motor weighs 6 to 9 kgr. (13.2 to 19.8 lb.) per H. P. but the author thinks it will be possible to improve on this.

The drawbacks of the type are the high cost, and the skilled staff needed for maintenance. The author hopes these drawbacks will become less serious. In any case a balance sheet has to be drawn up as between the operating costs and the purchase price.

The comparative costs for fuel in Canada are :

Oil	15
Coal	39
Distillate	90
Petrol	97

The author lays stress upon the need for the special and methodical instruction of the drivers and the repair staff.

The author then examines high power oil locomotives (1 540 H. P.).

The attached tables show that the different types show an appreciable saving of about 40 per cent for the petrol, over 50 per cent for the Diesel, and much more for the steam rail motor coaches.

II. — *Report by Mr. ZAVADJIL (Europe except France).*

The replies received by the Reporter were from the following countries : England, Denmark, Finland, Holland, Italy, Rumania, Switzerland, Yugoslavia.

The replies dealt with 157 rail motor cars as follows :

84 petrol: 62 with mechanical transmission; 22 with electric transmission.

55 steam (all English) — mechanical transmission or direct drive.

18 Diesel: 10 with electric transmission; 8 with mechanical transmission,

It should be noted that, in 1909, Mr. GRUPPI in his report mentioned 195 rail motors divided amongst 185 steam, 7 petrol and 3 accumulator.

This last type has disappeared, petrol has taken the place of steam, and finally, the Disel motor has made its appearance.

Most of the rail motor coaches are four-wheeled.

The petrol vehicles weigh 16 to 40 tons.

The Diesel vehicles, 22 to 63 tons. No information is available as to the English steam rail motor vehicles.

The weight per passenger is from 4 to 500 kgr. (880 to 1 100 lb.).

The average horse power is 3 to 3.5 per ton of weight.

The Reporter stresses the fact that Diesel motors nearly as light and as reliable as petrol motors, have been built.

The majority of the petrol vehicles has mechanical transmission — as being simpler and cheaper than the electric drive.

The Diesel motored vehicles have sometimes the one and sometimes the other transmission.

Most of the rail motor coaches can haul two light trailers but in actual working, only one trailer is attached.

The usual motor train carries 100 to 150 passengers of one class, third.

Two brakes are fitted, a hand brake and a compressed air brake of the railway type.

The heating is by hot water (engine cooling water).

In Switzerland alone, the exhaust gases are used for this purpose.

Electric lighting is fitted.

Out of the 157 vehicles considered, 98 have two driver's compartments, and 59 one only.

The petrol motors with mechanical transmission cost less as regards first cost than the Diesel engined vehicles.

Electric transmission considerably increases the cost price, and so reduces the margin between a petrol rail car and one with a Diesel engine.

CONCLUSION.

To sum up, there are two types of rail motor coaches.

1. Light type generally petrol (occasionally Diesel) of a maximum of 100 H. P., with mechanical transmission.

The number of seats is 50 and 1 or 2 trailers with 50 seats can be worked.

1. Heavy type weighing 25 to 40 tons of 180 to 250-H. P. Diesel motor. Electric or mechanical transmission (2 or 3 trailers).

The operating costs vary widely. The Reporter regrets that the lack of data prevents him from stating any precise conclusions on this point.

In any event, it can be stated positively that the cost is less than with steam.

Several companies state that the use of rail motor coaches has enabled them to meet the competition of road motors.

The companies using Diesel motors show a tendency to increase the power thereof.

III. — *Report by Mr. Paul BEGHIN (France).*

The report first of all recalls the circumstances in which the rail motor coach first made its appearance on the railways and the reasons why the Companies took up this form of transport.

It lays stress upon the advantage resulting from the reduction of dead weight per seat obtained as compared with the same factor in a light train working over a light railway company's line. Such a train with a single carriage having 32 seats gives a weight of 1 000 kgr. (2 200 lb.) per seat. He mentions rail cars having 32 seats weighing only 2.5 tons, or 80 kgr. (176 lb.) per seat.

Although the horse power-hour given by a petrol motor is much dearer in France than in the case of the locomotive, this reduction in weight makes it possible to effect a saving.

This advantage diminishes however as the number of passengers carried in the rail motor increases.

The motors of the rail cars described in the report are usually of the petrol mo-

tor car type. Diesel and semi-Diesel motors are little used. Suction gas motors are now coming into use.

There are few steam rail cars in use, those in service giving place to petrol motor coaches.

The Paris-Orleans Company however, is giving close attention to Sentinel steam cars of from 110 to 130 H. P.

One Company is using motors driven by nickel-iron batteries.

As a rule the transmission is mechanical. The electric drive gives a continuous range of speeds, but has the drawbacks of great weight and high cost.

Hydraulic and pneumatic transmission have not really been used.

The light rail cars have a single driving compartment : in some cases they are fitted with the Saurer and Tartary turntable arrangement for turning the vehicles.

The large rail motor coaches have as a rule two driving compartments.

The springing of the vehicles has been very carefully investigated in France.

It has been found that the simple spring gear with plate springs is not sufficient, and a combination of plate and coil springs has been developed whilst in addition lateral springing has been provided.

One builder only has introduced an elastic connection (rubber buffers) between the motor and the frame.

The report then gives a brief description of the various materials used in France.

The summary gives a table of the information supplied by the operators as regards the economic results obtained.

As it would be difficult to draw any precise conclusion from this table, the Reporter studies the question from the general point of view, and comes to the conclusion that there is a saving of 20 to 53 % in favour of the rail motor coach.

In addition, he points out that as the cost of a steam train does not increase in proportion to the number of places, whereas the cost of the rail motor car increases rapidly with its power, the economic value diminishes when the rail motor car reaches a certain capacity.

The Reporter concludes from the trials carried out that each time the Operating Department has allowed a rail motor coach to be substituted for a steam train, there has resulted a financial saving which will grow as this branch of industry progresses.

GENERAL CONCLUSIONS.

The three reports presented show that:

1. In France, up to the present, it has been the general practice to manufacture light rail motor vehicles fitted with petrol engines, the Diesel engine having so far been little used owing to its high weight and cost.

2. In Europe two types are in use :

A light type with a power of less than 100 H. P. usually fitted with a petrol engine and with mechanical transmission.

A heavy type of 180 to 250 H. P. with Diesel engine and with mechanical transmission.

3. In the remainder of the World, all these types are found with a strongly marked tendency in the United States to very high power using Diesel engines and electric transmission.

The reports unanimously agree in stating that when the power exceeds 150 H. P., electric transmission is essential, and all find an appreciable saving in the use of rail motor coaches.

[625 .172 & 625 .174]

QUESTION IV.

(RECENT IMPROVEMENTS IN PERMANENT WAY TOOLS, AND IN THE SCIENTIFIC ORGANISATION OF MAINTENANCE WORK) (1),

By Ch. H. J. DRIESSEN,
Special Reporter.

Question IV was dealt with in four reports drawn up respectively by Messrs.:

1. — D. Mendizabal (Belgium, France, Italy, Portugal, Spain and their Colonies) (2);

2. — Ch. H. J. Driessen (America, British Empire, Holland and Colonies, China and Japan (3);

3. — J. Hauer (other countries except Germany) (4);

4. — Dr.-Ing. Müller (Germany) (5).

Concerning the *Recent improvements in mechanical appliances* we find that many Administrations are proceeding, although usually slowly, to trials with mechanical tools, the exceptions being America, the Reichsbahn (German State Railway Company) and some French railways, where the use of machines for maintaining the track is already extensive.

Passing in review the various cases contemplated in the questionnaire we find that the *loading, transport and unloading of the ballast* is done by nearly all the Administrations in a special manner, either with self-discharging wagons or with ordinary wagons using cranes for unloading. The advantages resulting from the use of these wagons are so evident that it is astonishing that their use has not become universal.

The unloading of rails is still too often done without special plant. The method of sliding them down, skids placed against the wagons, entails the risk that for want of time or other reasons the men let the rails fall on to the ballast and bend the ends, a defect which can only be made good with great difficulty. On the Reichsbahn especially, cranes with horizontal shafts are employed, and are attached to the floor of the flat wagon, whilst in America and elsewhere mobile cranes are used which serve also for many other operations. In the Netherlands, a very simple arrangement is used allowing two rails to be unloaded longitudinally by moving the wagon forwards, whilst the rails to be unloaded are anchored by means of ropes to the track.

Rolling the ballast is only practised by the Reichsbahn and is said by them to be very satisfactory. It is certain that whenever a renewal of the roadbed can be carried out by placing the track out of service, rolling of this bed should be considered, seeing that this rolling will prevent to a large extent the settling of the ballast under the weight of the trains.

Laying sections of complete track is only done in America at special posi-

(1) Translated from the French.

(2) See *Bulletin of the Railway Congress*, January 1930, p. 9.

(3) See *Bulletin of the Railway Congress*, February 1930, p. 385.

(4) See *Bulletin of the Railway Congress*, March 1930, p. 1029.

(5) See *Bulletin of the Railway Congress*, March 1930, p. 1079.

tions like points, cross-overs, etc., since the American custom of renewing the sleepers precludes the entire renewal of rails, sleepers, etc., at one time. In Germany several methods are employed for the renewal of portions of the complete structure, a practice which without, being general, seems to have already passed the trial stage. Although the report does not make mention of it, attention may be drawn to the method of the French Nord Railway regarding the complete renewal of the track and of the roadbed which has been described by Mr. Tettelin in the *Revue générale des Chemins de fer* of October 1929.

For *the carriage of materials along the track*, small cars called « poney-car » and « dandy-car » are largely used, although some Administrations use motor lorries, or even trains of tipping wagons when it is a question of shifting large quantities. It may be remarked that it is of advantage to avoid as much as possible the moving of materials other than by the wagons which carry them between the warehouse and the place where they are to be dumped, or vice-versa removed from the road, taking care that the materials are unloaded at the actual spot where they are to be laid, and that those which are taken from the track shall be loaded directly on to the wagons which take them to the central store or to the place where they will be used again.

Drilling and adzing the sleepers is nearly always done by machine and preferably at the impregnating depot, especially by the Administrations which use a track with cast iron chairs or a similar construction (like the Reichsbahn which has replaced the chair by a rolled base plate). In order to prolong the life of the sleepers it is very advisable to do the drilling and adzing before impregnation.

Distributing and placing the sleepers is done exclusively by hand labour, the sleepers being unloaded close to the spot where they will be placed in the track.

It is only in America that a special machine is used for laying the rails called the « Madden rail-layer » this being due to the American practice of replacing sleepers when necessary, one by one and therefore of laying the new rails on sleepers which are already in the track.

Driving the coach screws of the chairs (and of the rolled base plates which take their place) is generally done in the workshops by fixed machines. In some cases electrically operated machines are employed out on the track.

Only in isolated cases is the *tightening of the fishplate bolts* done by pneumatic or electric tools. Mention is also made of a special spanner which enables the work to be done at a greater speed during the process of bolting up and which does not require any great effort, whilst the tool works as an ordinary spanner when the nut has to be finally tightened. It is however, doubtful whether the same advantage would not be obtained by using alternately a small spanner and a normal spanner.

Spreading the ballast is done in a few instances only in America with high speed machines.

For straightening and levelling the track crow-bars or levers are now hardly ever employed, jacks being almost universally used in their place.

Tamping the ballast is very often done by means of mechanical tampers, either pneumatic or electric. Of the first there are two types : one in which a petrol motor with a small compressor placed alongside the track serves two tampers (an arrangement which has not always given satisfaction), and the other where a motor with a larger compressor mounted on a car, which during the work is removed from the track by means of small transverse wheels, serves up to twelve tampers.

Weeding the ballast is done in some cases by machines which burn the weeds or by others which turn over the ballast like a plough, tearing up the weeds. However, the manipulating of such machines being very difficult, it would seem that for weeding the track there is a good future for chemical means. In our opinion it is very desirable to continue the trials mentioned under this heading, as the necessary equipment is not expensive.

Screening the ballast is done, especially in America, in several cases by mechanical means, either by cranes with grab buckets, which dump the ballast on to a wagon with screens or by an arrangement called « McWilliams mole », whilst the French Nord Railway employs a very special machine for sifting the ballast simultaneously with the complete renewal of the track. (*Revue générale des Chemins de fer*, October 1929).

Straightening, cutting and drilling the rails is done by tools which in some cases are motor driven.

Amongst the machines which are grouped under the heading « *For any other purpose* » we cite those for oiling the running side of the rails on curves, in order to lessen wear. It would seem that this practice is an effective means for reducing wear, particularly at crossovers at the entrance to main stations, and that it deserves to be given attention.

From the reports it may be concluded that both petrol driven and electric machines are capable of meeting all requirements whilst cranes are generally steam driven.

The economic advantages in several cases seem to be considerable, a saving of as much as 50 % being claimed. It is evident however, that these economic advantages depend very largely on the manner in which the machines are used, and in order to be able to determine the value attributable to the figure which is given as expressing the advantages, it is necessary to know how this figure has been reached. Unfortunately no such indications are given in the reports (it is only Dr. Müller's report which gives a summary of the total expenses of using such a machine). Supposing it is desired to ascertain if a certain operation which is only part of the whole job — for instance, screwing up the bolts — can be done economically with a certain machine, one cannot — in order to determine the economy of this machine — take into consideration a period of only two hours during which the machine is constantly working, whereas during several following hours no use can be made of it owing to other portions of the job having to be carried out. The saving thus estimated would be much too high. It is necessary to consider the whole of the work to be done. From the replies received it is apparent that this point of view has been lost sight of.

It is evident that a good output from the machines can only be expected if their use is strictly regulated, that is to say it is imperative to draw up a working programme.

Beside the economic advantages which can result from the use of machines, other advantages may be expected, as for instance better work, less fatigue to the workmen, more rapid execution of the work, and greater output in case of shortage of labour.

The use of several machines requires that the track is out of use, which will often be a serious obstacle. Administrations, for example, who are accustomed to renew the track without interrupting the normal running of the trains cannot make use of machines which lay completely mounted sections of track nor of machines for rolling the bed, except when these works can be carried out during the night, although this involves serious inconvenience.

Therefore, Administrations will do well, in taking into account local conditions such as the extent of the line, cost of labour, density of traffic, etc., to ask themselves which operations for maintaining the track can be done by mechanical tools, and if favourable conditions offer to them, proceed to a trial, carefully ascertaining the economic advantages or otherwise, and finally to decide if mechanical plant for the operation in question ought to be generally introduced.

In the rational organization of track maintenance very little change has taken place during recent years. In all the Administrations, the maintenance of the track is done by brigades or gangs, the personnel of which is uniformly distributed along the line, whilst only a few Administrations have gangs which have no settled district, but are employed for special work, such as renewing the track, general revision, etc. The Reichsbahn only, has a totally different organization. Each gang, of which there are usually two to three per district, has no defined territory, but works within the limits of the district at the spot where the work has to be carried out, gangs being combined if the extent of the work requires it.

A great many, and very different, measures have been adopted having for their object the more economical maintenance of the track, such as the reduction of the number of men in a gang and the increase of the number of gangs; extending the area of the gangs by introducing auto-cars for transporting the men and the materials; reducing the number of men in a gang during the winter; the introduction of maintenance by general revision; the use of flying gangs in districts where labour is scarce. It will depend on local conditions whether one or more of these measures will give the desired result, but it is quite generally recognized that the method of general revision leads to a better and more economical maintenance.

The particulars given of the equipment of the main lines lead in our opinion to the conclusion that it is economical to use heavy rails, close spacing of the sleepers, and good quality ballast. The best method of fixing the rails on the sleepers is in our opinion either the « Est » system (using hard wood sleepers) or a system with separate attachment, that is to say that the parts for fixing the rail on the chair or on the base plate are not the same as those which fix the chair to the sleeper.

There is such diversity, as much in the length of the road to be maintained by a gang as in the strength of the gangs, and even in the length of the road which serves as the basis for calculating the number of men necessary for its maintenance, that a knowledge of the figures has no value. From a study of the replies received it may be concluded that the only rational basis for establishing the number of men necessary for maintenance is the length of equivalent track, and that therefore the use of formulæ is indispensable. Therefore, too much care cannot be given to the introduction in these formulæ of all the factors which bear on the difficulties of maintenance, giving them their appropriate coefficients. Among these factors we cite : the length of several categories of track (main lines, sidings, turnouts, goods lines, tunnels), points and crossings for the different categories, weight of the rails, quality of the ballast, number and speed of the trains (classification of the line), gradients and curves, level crossings, ditches and fences, signals and protecting apparatus (if the gang has to maintain these), stations (for instance, ash pits), etc. If one considers the number of men resulting from the application of the formulæ as a basis for fixing the strength of the gangs, and examines all the instances where it is necessary to

deviate from this basis, one may in our opinion hope to arrive at a rational distribution of the personnel.

Very generally the number of workmen is greater in summer than in winter, the brigades being strengthened in summer by temporary workmen. Here, it is necessary to distinguish between the normal work of maintenance and special work. Of course for such work which is not done every year, temporary workmen are employed (unless special flying gangs are used) but there are also some Administrations which have also for normal work a different force in summer and winter, which in our opinion leads to an appreciable economy.

The method of maintenance by general periodical revision is not nearly so extended as it deserves to be, many Administrations adopting the method of maintenance by walking the line. We certainly think that maintenance by general revision is economical and results in a well kept track, whilst an efficient control of the personnel is possible. The general revision should be considered the most important work of the gang; it should be done before any other work. Consequently it would not be just to entrust this work to special gangs. There are only very few Administrations which have certain works carried out by their personnel by piece work, or which grant premiums for carrying out certain work within a fixed period. Besides objections in principal (as in America) it is feared that the quality of the work may suffer. However, we, as well as the Administrations which have inaugurated the system of granting premiums, believe that the workmen who profit thereby would not like to be deprived of this system; and that the fear the work would not be properly carried out is not justified.

Concerning the hours of labour, it is sufficient to remark that the 8-hour day (48 hours per week), or a period which does not depart materially therefrom, is fairly widespread, and that in several cases the day is longer in summer but shorter in winter than the normal day. In urgent cases the normal day may be exceeded (generally up to a certain limit) the extra hours being paid for at overtime rates, or being deducted from the following days. Except in very rare cases the working time does not begin to be counted until the moment when the workmen arrive at a designated spot, either the gang hut, or a gang depot, or a station, or the place where the work has to be done.

It is only in America that the practice of taking the workmen to their work by means of auto-cars is general. These cars run nearly always at the responsibility of the guard who takes his instructions from the traffic inspector, which we consider the only possible practical method of circulation. If written orders were required for the circulation of these auto cars, or, still worse, if they are considered as a train, their liberty of circulation would be so restricted that they would suffer a considerable loss of time.

Amongst the special measures for increasing the life of the materials in the case of heavy traffic (measures which may however, be partly useful for other roads) we find the use of heavy rails, special steels such as sorbitic steel for rails and points, hard wood for the sleepers, heavy base plates, ballast of hard broken stone, increase in the number of sleepers, oiling the fish plates and the running sides of the rails in curves, etc.

The use of graphs of the progress of all work, with an indication of their economic results, is not general. It is probable that although such graphs may show important data, most of the railways are afraid of burdening their personnel, and particularly the gang foremen, with accountancy of this character, and they believe they can determine the

economic results from a portion of the work when the opportunity arises.

Usually the gang foremen are recruited from the plate layers. There are a few Administrations who have instituted or favour courses of instruction for gang foremen, but the majority are satisfied with practical instruction, in some cases making the platelayers undergo a simple examination before being nominated as gang foremen.

Although in some cases the district foremen are chosen from the gang foremen, most of the Administrations require them to have had a fair education, and making them undergo a probationary period before definite nomination, whether or not accompanied by regular classes.

FINAL CONCLUSIONS.

1. The track work which is usually done with special tools (apart from the use of small tools like jacks, poneycars, etc.) are :

a) Unloading the ballast by means of special wagons;

b) Tamping the ballast by means of pneumatic or electric tampers;

c) Cleaning the ballast by chemical means.

2. Track work for which mechanical tools deserve to be considered are :

a) Unloading of rails;

b) Rolling of ballast;

c) Laying of complete sections of track;

d) Oiling the running side of rails in curves.

3. Apart from cranes which are usually driven by a steam engine we find that both pneumatic and electric machines will meet all needs.

4. The economic advantages are in several cases very appreciable and show savings of as much as 50 %. In order to get a good output from the machines, it is necessary to regulate strictly their use by drawing up a programme of work.

5. Apart from economy, the use of machines can lead to other advantages such as better work, less fatigue for the workmen, work carried out in shorter time, and the possibility of making up for a shortage of labour.

6. Gangs or brigades entrusted with the maintenance of the track are nearly everywhere uniformly distributed along the lines. The use of flying gangs for special work, such as the renewal of the track, might be taken into consideration; it is important to entrust the gang with all work connected with the maintenance of the track, in view of its responsibility for the good condition of the track, and for the safe passage of the trains.

7. In the organization for maintaining the track, several innovations have been introduced, having for their object a more economical maintenance. The chief innovations are : the introduction of maintenance by general revision; reducing the strength of the gangs in winter; increasing the area covered by the gang by the employment of auto-cars for transporting men and materials.

8. The length of the road to be maintained by a brigade and the strength of the brigades differ within wide limits. The only rational basis for determining the number of men required for maintenance is the length of equivalent track, which is to be calculated by means of formulæ. It is necessary to introduce into these formulæ all the factors bearing on the maintenance, giving them their appropriate coefficients.

9. Maintenance by general revision is to be recommended, not only as an economic measure, but also in order to have an effective control of the personnel entrusted with the maintenance of the road.

10. There are only a very few Admini-

strations who have certain work carried out by their personnel by piece work, or who grant premiums for the execution of certain work within a fixed period. Nevertheless, this practice deserves attention, as much from the economic point of view as in the interest of the workmen, the fear, that the quality of the work will suffer, not being justified.

11. The 8-hour day, (48 hours per week) or a period which does not materially depart therefrom, is fairly general. Often in summer the day is longer, but in winter shorter, than the normal day.

12. Generally the working time begins to count from the moment when the workman arrives at the designated spot, either the gang depot or a station, or the place where the work has to be done.

13. The use of auto-cars to take men to their work is not very general, and is only indicated in cases where habitually the work is begun at a spot (depot, station) other than that where it should be normally.

14. For augmenting the life of the materials used, the following measures are to be recommended : the use of heavy rails, special steels (for instance sorbitic steel) for rails and points, hard wood for the sleepers, heavy base plates, broken hard stone for ballast, increasing the number of sleepers, lubricating the fish plates and the running side of the rails on curves, repairing worn parts.

15. The use of graphs showing the progress of all works, with indications of the economic results obtained, is not very general. It is doubtful whether the heavy work which the preparation of such graphs demands is proportional to the advantages they give.

16. The general custom of recruiting the gang foremen from the platelayers, and of giving them an exclusively practical education, gives satisfaction.

17. In general, an average standard of education is required of district foremen, who must pass through a probationary period which may, or may not, include regular classes before definite appointment.